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Cosmonauts Continue Mission Experiments

LD1409151790 Moscow TASS in English 1412 GMT 14 Sep 90

[Text] Moscow September 14 TASS—TASS correspondent reporting from the Mission Control Center:

In the past two days Gennadiy Manakov and Gennadiy Strekalov conducted experiments in space materials science and geophysical research.

On September 12 the crew held a scheduled melting experiment on the Gallar device. The nine-day experiment involves growing a high-quality monocrystal of the semiconducting material gallium arsenide.

A set of videospectral equipment on the Kvant-2 module was used to take photographs of parts of Soviet territory. The main aim is to examine the state of Siberian woods in order to spot fire-hazardous areas. Information was promptly beamed back to earth.

The cosmonauts have unloaded the Progress M-4 spacecraft and loaded it with used equipment. Final operations in refuelling tanks of the station with fuel and oxidizer are being completed now.

According to telemetric information and reports of the crew, the on-board systems of the Mir complex function normally. The cosmonauts feel well.

'ProgressM-4' Separates From 'Mir', Plasma Experiment To Be Performed

LD1709144290 Moscow TASS in English 1431 GMT 17 Sep 90

[Text] Moscow September 17 TASS—The unmanned Soviet cargo spacecraft Progress M-4 disembarked from the Mir space station at 16:43 [1243 GMT] Moscow time today.

During the joint flight of Mir and Progress M-4, cosmonauts Gennadiy Manakov and Gennadiy Strekalov carried out all planned operations, including unloading, refuelling, oxygen recharging and potable water transferring.

The cosmonauts used Progress M-4 engines to correct the space station's trajectory.

The cargo spacecraft is planned to remain in space until September 20. During its independent flight, an experiment will be held to study artificial plasma formations. To this end, the cosmonauts installed experimental equipment on the docking unit of Progress M-4.

Manakov and Strekalov, who have been in space for almost seven weeks, began their working day today with medical experiments. They studied Manakov's blood circulation system during exercises on a bicycle ergometer.

They also continued an experiment on the Gallar installation to grow gallium arsenide semiconducting material, which was started on September 12.

The cosmonauts are feeling well.

TASS Reviews Cosmonauts' First 50 Days Aboard 'Mir'

LD1909210190 Moscow TASS in English 2031 GMT 19 Sep 90

[By TASS correspondent Rena Kuznetsova]

[Text] Moscow September 19 TASS—Gennadiy Manakov and Gennadiy Strekalov have been working on board the Mir space station for 50 days.

They have carried out a considerable part of the program, dozens of soundings of the earth's surface in the interest of the national economy and unloaded the automatic cargo spacecraft Progress M-4.

On Wednesday, the cosmonauts were involved in medical researches. They have tested the state of the flight commander's cardiovascular system with the help of special equipment. The cosmonauts have conducted prophylactic work and geophysical research of the earth's atmosphere.

During the flight, they have fulfilled the program of materials' study and conducted a melting experiment on the Krater-V installation, that took 260 hours. They have obtained a semiconductor material, zinc oxide, used in the radioelectronic industry, and have grown a monocrystal of another semiconductor, gallium arsenide, on the Gallar apparatus. The experiment lasted for 240 hours.

The cosmonauts are also monitoring the state of ecology in some regions of the Soviet Union. The research is conducted with the help of videospectral equipment installed in the Kvant-2 module. a special photo unit, Priroda-5, installed in the Kristall module, is used to study the earth's mineral resources. It is also used for ecological monitoring.

'Progress M-4' Spacecraft Completes Mission

LD2009135990 Moscow TASS International Service in Russian 1257 GMT 20 Sep 90

[Text] Moscow, 20 Sep—TASS special correspondent reports from the flight control center: The "Progress M-4" automatic transport craft, which delivered to the "Mir" station more than two tons of various cargoes, has completed its flight. Today, at commands from the Flight Control Center, the cargo craft was oriented in space and at 1504 Moscow time [1104 GMT] its engine was switched on. As a result of braking, the "Progress M-4" craft went into a descent trajectory, entered the dense layers of the atmosphere and ceased to exist.

During its automatic flight the crew observed and recorded artificial plasma formations injected by a device installed on the cargo craft.

In accordance with the plan of work the cosmonauts spent a working week investigating the functional condition of the cardiovascular system using a multicardiographic and an ultrasonic method. An appraisal was made of the set of physical training exercises.

On the "Gallar" installation a nine-day cycle of growing gallium arsenide semiconductor material is being completed. Work is being conducted in preparation for switching on the "Krater-V" electric furnace.

According to telemetric data and the crew's reports, the onboard system of the "Mir" complex are functioning normally.

'Progress M-5' Cargo Spacecraft Launched

LD2709134690 Moscow TASS in English 1340 GMT 27 Sep 90

[Text] Moscow September 27 TASS—The Soviet Union launched an unmanned cargo spacecraft today in keeping with a program of work on board the scientific research platform Mir (Peace).

The freighter, Progress M-5, carries expendable materials and other cargoes for Mir.

It also carries, for the first time, a prototype of recoverable ballistic capsule, which will be used in the future to return the results of scientific studies to earth.

According to telemetry data, the freighter's on-board systems are working normally.

Cosmonauts Conduct Geophysical Research

LD2509140890 Moscow TASS in English 1355 GMT 25 Sep 90

[By TASS correspondent at the "Mission Control Center"]

[Text] Moscow September 25 TASS—Cosmonauts Gennadiy Manakov and Gennadiy Strekalov continue working aboard the orbital complex Mir. The research program being implemented during the flight includes astrophysical, geophysical and technological experiments.

By means of the Buket and Granat spectrometers, designed at the Moscow Engineering Physics Institute and the Leningrad Physics and Technology Institute, the cosmonauts gauge spatial and energy characteristics of X-ray, gamma-ray and neutron radiation of cosmic origin along the flight path of the manned orbital complex.

Under the geophysical research plan, the space crew go ahead with experiments to determine the spectral characteristics of the "space-atmosphere-surface" transitional zones in infra-red and visible wavebands. The cosmonauts use instruments mounted on the remote-controlled stabilised platform of the Kvant-2 module.

The cosmonauts launched a 14-hour cycle to grow high-quality monocrystal of zinc oxide on the Gallar technological installation.

The cosmonauts are in good health. The flight is proceeding according to schedule.

'Progress M-5' Docks With 'Mir' Station

LD2909141290 Moscow TASS International Service in Russian 1330 GMT 29 Sep 90

[Text] Moscow, 29 Sep (TASS)—Today at 1627 Moscow time [1227 GMT], the automatic cargo ship Progress M-5 docked with the manned station Mir.

The mutual location, approach, mooring, and docking took place with the aid of the on-board automated equipment. These processes were monitored by the Flight Control Center, and also by cosmonauts Manakov and Strekalov.

The ship Progress M-5 docked with the station at the side of its transfer module. The orbital deliveries included fuel for the consolidated propulsion unit, food, water, equipment, instruments, and mail.

According to the telemetry information and the crew's reports, the on-board systems of the Mir station are working normally. Gennadiy Manakov and Gennadiy Strekalov feel fine.

Cosmonauts Adjust 'Mir' Orbit

LD0210132190 Moscow TASS in English 1313 GMT 2 Oct 90

[By TASS correspondent from the Mission Control Center]

[Text] Moscow October 2 TASS—The ninth week of the two Soviet cosmonauts' stay in orbit is over. In the past days Gennadiy Manakov and Gennadiy Strekalov engaged in astrophysical, technological and technical experiments, routine preventive maintenance work aboard the orbital station and modules, and the transfer of cargoes from the Progress M-5 automatic supply cargo spacecraft.

Under the research plan, the cosmonauts continue experiments to gauge spatial-and-energy characteristics of cosmic-ray radiation and to evaluate the effect of open space factors on the properties of various structural materials mounted on the outer surface of the station.

A regular cycle of the growing of semiconductor monocrystals of zinc oxide has been completed on the Gallar technological installation.

Today the crew are replacing the equipment of the heating loop of the station's thermal regulation system and are testing the onboard television equipment via a relay satellite.

On Monday [1 October] the crew carried out an adjustment of the flight path of the orbital research complex Mir by means of the Soyuz TM-10 transport spacecraft.

The parameters of the spacecraft's orbit following the adjustment are as follows:

—the maximum distance from the earth's surface—439 kilometres,

—the minimum distance from the earth's surface—379 km,

—orbital period—92.4 minutes,

—inclination—51.6 degrees.

The cosmonauts are feeling well. Work in orbit is going on.

Cosmonaut Explains Crystal-Growing Project

PM0310133590 Moscow Television Service in Russian 1700 GMT 29 Sep 90

[Report by P. Orlov; from the "Vremya" newscast]

[Text] [Announcer] The Progress M-5 cargo spacecraft docked with the Mir orbital complex today.

[Cosmonaut's voice] It is floating in nicely... God willing... [video shows Progress craft approaching]

[Reporter] The Mir station is flying above the forests, above the seas, and above the heads of the taxpayers, who are not exactly enraptured by this. This is how the station's camera perceives the approaching Progress M cargo craft, part of which will return to earth with freight. What freight? Gennadiy Strekalov has the details.

[Cosmonaut Strekalov, holding up capsule] This capsule contains gallium arsenide crystals in this [words indistinct].

[Reporter] Is the whole thing crystals?

[Strekalov] Yes, inside this very thin wrapper there are smelted finished crystals. Specialists on earth will unwrap and analyze them. We hope that they are large, high-grade crystals. They will be directly put to use, they will be used in new electronic circuits, and so forth. They are ready. They will be returned to earth in these containers. [video shows container] There are also other furnaces aboard the orbital complex. Specimens of this kind, of this size, will also be smelted. [video shows specimens] I would like to show you an example of a small failure of ours. This is one of the specimens that went wrong. However, specialists have worked out the reason, and we are hoping to continue our work in obtaining crystals. When it comes to technology, not everything always goes smoothly, you understand.

[Reporter] Weightlessness alone makes it possible to adjust and test the function of all the systems in the proper conditions.

[Strekalov] Weightlessness is simultaneously our enemy and a good ally. We could not obtain these crystals without weightlessness.

[Reporter] So why the hurry? Why transport these specimens now, without waiting for the end of the expedition? First, because for a long time now, it has been impossible to fit everything into one spacecraft. And second, because for many years the delay in processing space results has cost us a great deal of money.

I would like to mention one more thing. Something that has come to light today. The mere fact of admitting that something has gone wrong in space demands great courage on the part of the crew. Pure human courage, just like, incidentally, any other job in orbit.

Mir Cosmonauts To Conduct EVA for Airlock Repairs

LD0510134190 Moscow TASS in English 1321 GMT 5 Oct 90

[By TASS correspondent at the Mission Control Center]

[Text] Moscow October 5 TASS—Two Soviet cosmonauts on board the orbiting platform Mir (Peace) prepared today for the forthcoming spacewalk to repair a faulty airlock joint on a module that is part of the complex. The instrumented module is called Kvant-2 (Quantum-2).

Gennadiy Manakov and Gennadiy Strekalov also prepared the technological system Gallar for another 240-hour experiment to grow gallium arsenide, a semiconductor material.

They have thus fully completed scientific and technological studies and experiments planned for the past week.

Using the Kap-350 camera and instruments installed on Kvant-2's remote-controlled [?gyrostabilised] platform, for instance, they did photography and spectrometry studies on parts of Soviet territory.

The studies were to ascertain the influence of human anthropogenic activities on vegetation and soil and investigate the tectonic and geological structure of the earth.

In preparation for a planned visit by a Japanese journalist, the cosmonauts installed extra television equipment brought by the Progress M-5 cargo craft and tuned it up, with the help of ground services, for direct broadcasts to Japan through a relay satellite.

Cosmonauts Prepare for 19 Oct EVA

LD1210114990 Moscow TASS in English 1057 GMT 12 Oct 90

[Report by TASS correspondent from the Mission Control Center]

[Text] Moscow October 12 TASS—Soviet Cosmonauts Gennadiy Manakov and Gennadiy Strekalov, the crew of the seventh main expedition, continue their flight on board the orbital research complex Mir.

The cosmonauts regularly measure x-ray, gamma-ray and neutron radiation of extraterrestrial origin under the program of astrophysical experiments by means of the Buket telescope and the Granat spectrometer mounted on the Kristall module.

The cosmonauts continue to monitor the process of growing semiconductor monocrystals under the space technology program on the Gallar and Krater-B installations.

Under a medical control plan, Manakov and Strekalov on Thursday underwent thorough checkup of the cardiovascular system with a dosed physical load.

This morning the crew, in order to study the environment by means of video spectral equipment, photographed individual areas along the flight path over the Caucasus, the Caspian Depression, and the Aral Sea.

The cosmonauts are preparing workplaces and space suits in view of their space walk scheduled for October 19.

Solar Panel Transfer Planned

LD1210054890 Moscow Television Service in Russian 1800 GMT 11 Oct 90

[Editorial Report] Moscow Television Service in Russian at 1800 GMT on 11 October, during its regularly scheduled "Vremya" newscast, broadcasts a three-minute video report by correspondent P. Orlov from the Cosmonaut Training Center; date not given.

Orlov begins by noting cosmonauts Gennadiy Mikhaylovich Manakov and Gennadiy Mikhaylovich Strekalov will make their first spacewalk 19 October, when they attempt to fix the Mir orbiting station's hatch problems.

Orlov interviews Musa Manarov, a cosmonaut training for a December spacewalk, who says that if the October mission fails he and Commander Afanasyev will have to complete the work in December.

Orlov says that, if everything goes well with the hatch, the cosmonauts will have to prepare the station for transferring solar batteries from module to module.

One of the Mir cosmonauts then explains that the Mir furnaces consume a lot of energy and that, as the complex grows overall, more energy is required and a greater area for solar batteries is needed.

Orlov concludes the report by confirming the battery work will be carried out after the 19 October spacewalk.

19 Oct Space Walk Postponed, Rescheduled 30 Oct

LD1810110390 Moscow TASS in English 1042 GMT 18 Oct 90

[By TASS correspondent Rena Kuznetsova]

[Text] Moscow October 18 TASS—A space walk by Soviet cosmonauts Gennadiy Manakov and Gennadiy Strekalov, which was originally scheduled for October 19, has been postponed and tentatively slated for October 30, Pilot-Cosmonaut of the USSR Valeriy Polyakov, deputy director of the USSR Health Ministry's Institute for Medico-Biological Problems, told TASS.

The two cosmonauts have been working aboard the Soviet orbital complex Mir for more than two and a half months now.

"The reason for the postponement is quite simple. A cosmonaut is, naturally, not a robot or automaton. He remains an ordinary human and, unfortunately, is susceptible to ailments lurking in his path even in orbit," Polyakov said.

"Due to a slight overcooling by on-board fans after a 'running track' training session, the flight engineer caught cold.

"During tests, the cold became apparent in Strekalov's declining capacity for work," Polyakov said.

"However, this in no way influenced the implementation of the flight program," Polyakov added. "But, considering the entire complexity of extravehicular activities, medical specialists and the mission control centre took, to my mind, quite a reasonable decision to postpone a space walk."

The flight engineer does not need any special treatment. He merely took ascorbic acid, which is in the first-aid kit on board. Physicians on earth agreed with his action. There was no need for any other (medical) adjustment.

During the space walk, the cosmonauts will repair the egress hatch positioned on the Kvant-2 module.

During the flight of the sixth main expedition—Anatoliy Solovev and Aleksandr Balandin—the hatch failed to close. The malfunction was later corrected by the cosmonauts during the subsequent space walk.

The seventh expedition crew are to check the hatch and do everything possible for it to function without any hitch.

The postponement of the space walk until October 30 somewhat disconcerted Strekalov, who would prefer to walk in space on October 28, on his 50th birthday

TASS Updates Cosmonauts' Activities

LD1910123990 Moscow TASS in English 1203 GMT 19 Oct 90

[Text] Moscow October 19 TASS—Soviet cosmonauts Gennadiy Manakov and Gennadiy Strekalov have been conducting material studies and geophysical research during the past two days.

They have completed a long-term technological process on the Krater-8 installation to grow a monocrystal of gallium arsenide. The experiment was started on October 8.

With the help of videospectral instruments, installed in the stabilised platform of the Kvant-2 module, and the photographic Priroda-5 complex, the cosmonauts photographed central and southern parts of the Soviet Union.

A series of experiments with the use of the Ferrit and Danko apparatus helped assess physical and mechanical characteristics of structural materials under the influence of open space.

On Friday, the crew are expected to study the ecological situation in the regions near Chernobyl, the Volga, the Aral and Black Seas. Cosmonauts will replace a block of hydraulic [word indistinct] in the thermal regulation system.

Austrian Cosmonaut Candidates Train for 1991 Mir Mission

LD1910215690 Moscow TASS in English 1950 GMT 19 Oct 90

[By TASS correspondent Rena Kuznetsova]

[Text] Moscow October 19 TASS—Two Austrian pilots—Clemens Lothaller and Franz Viehboech—are now in training for a place on board a mission to the Soviet orbital station Mir.

One of the two men will go to the orbital station with his Soviet colleagues in 1991.

The two Austrian candidates for the flight are also taking a crash course in Russian, the language they will speak with other crew members on Earth and in space. Physical training and sports are on the training program as well.

A Glavkosmos spokesman told TASS that the international crew is expected to fulfil an extensive research and experiment plan in the interests of the two participating countries' economies.

The plan centers around medico-biological research and the remote survey of Austrian territory. An extensive exposition, devoted to the forthcoming space trip, research and experimentation work the crew will perform in space, is expected to go on view this month in Austrian cities Graz and Innsbruck.

Cosmonaut's Ill Health Delays Spacewalk

PM2210151790 Moscow Television Service in Russian 1800 GMT 18 Oct 90

[Report by P. Orlov; from the "Vremya" newscast]

[Text] [Announcer] There has been an unexpected change in the plans of the seventh main expedition—Gennadiy Manakov and Gennadiy Strekalov—to the "Mir" station. You can learn the details from a reportage by our correspondent Petr Orlov.

[Reporter] On Friday, 19 October, the crew was to leave the station to repair the hatch and to prepare the station for the new solar batteries. However, during a medical checkup session doctors raised the alarm. According to objective tests the board engineer's capacity for work is greatly impaired. This is the scientific formulation. In plain language, Gennadiy Strekalov has a cold. Where did one of our most experienced cosmonauts catch a cold? It appears that it happened on the biccycle ergometer. As you can see, Commander Gennadiy Manakov just assembling it. Gennadiy Strekalov simply caught a cold by being in a draft. And that is no joke. The highly fit cosmonauts can be incapacitated practically by only two things—psychological incompatibility with the earth or within the crew, and drafts. The air does not circulate of its own accord on the "Mir" station, and there are no ventilation windows, of course. The air is moved by fans. This is how Gennadiy Mikhaylovich Strekalov caught his cold. The rest is no different from what happens on earth—doctors have forbidden him to go out. The cold treatment is also orthodox—aspirin and ascorbic acid. So the flight engineer will have to sweat it out. Not in the spacesuit, but inside the station. Incidentally, the same amount of time for cold treatment treatment is allowed in space as on earth—seven days. No sick notes are issued, however. So the cosmonauts continue to work. Today they adjusted the remote camera located outside the station and can photograph the earth with greater precision than ever before. This is needed for geophysical research and agriculture.

As for the cold—the Americans, for instance, had to put off a shuttle launch because of the commander's cold. And we have had to put off our spacewalk until 30 October.

Cosmonauts Continue Experiment Program

LD2310153690 Moscow TASS in English 1300 GMT 23 Oct 90

[Text] Moscow October 23 TASS—Cosmonauts Gennadiy Manakov and Gennadiy Strekalov continue to carry out experiments aboard the Soviet Mir space station.

They have used the Gallar installation to produce gallium arsenide semi-conducting monocrystals in conditions of weightlessness. The experiment was carried out within the framework of an extensive space technology programme.

Spectrometer devices installed outside the Kvant-2 module were used to carry out a series of astrophysical experiments to measure solar radiation.

The crew has prepared for work the Svet greenhouse created by Soviet and Bulgarian specialists for fresh experiments and studies of the development of superior forms of vegetation in space conditions. Radishes and lettuce will be grown this time.

Under a plan for medical check-ups, the cosmonauts have been subjected to an examination to define how their cardiovascular systems react to measured physical load.

EVA To Repair Hatch Unsuccessful

PM0111141190 Moscow Television Service in Russian 1800 GMT 30 Oct 90

[Report by P. Orlov, A. Kudeli; from the "Vremya" newscast]

[Text] [Announcer] Last night cosmonauts Gennadiy Manakov and Gennadiy Strekalov carried out a spacewalk.

[Kudeli] Ensuring a reliable fit between the hatch cover and the body of the Kvant-2 module—this is how the objective of the task entrusted to Manakov and Strekalov was specified in the final report. Would you believe someone who told you that he was flying to Sochi only in order to travel on an airliner? Of course, not. The same applies here. Naturally, what they wanted to do was to completely repair this unique one-meter hatch. Now this will have to wait until next time. It is not that the crew were lacking in skill. In two hours and 45 minutes they did what they could. But the damage proved much more serious than was thought.

Why is such a determined assault being mounted on this intractable hatch by the second crew in succession? How important is it for our space plans?

[Orlov] The point is that without this hatch, this one-meter hatch, the further development of the station, the buildup of its solar batteries, and the installation of new specialist equipment in outer space is simply impossible.

Even this [video shows model of Mir space station] is not the final version of the Mir complex. It must be developed further. To smelt crystals and conduct increasingly complex scientific research, it must be further expanded. Only then will it be truly efficient. It is annoying that we are having to begin construction with repairs.

Cosmonauts Begin Fourth Month in Space

LD0211144190 Moscow TASS in English 1430 GMT 2 Nov 90

[Text] Moscow November 2 TASS—Soviet cosmonauts Gennadiy Manakov and Gennadiy Strekalov have begun their fourth month of work in space.

This week's plans included, in addition to operations outside the space station, material research in weightlessness and astrophysical observations.

The Gallar installation was used to melt materials to obtain monocrystals of semiconducting gallium arsenide.

The magnetic spectrometer Mariya helped in a series of experiments aimed at studying the mechanism of elementary high energy particles generation and their proliferation in near-Earth space.

Today, Manakov and Strekalov undergo medical tests, which include being weighed, testing muscle strength after three months in space, blood analysis and audio tests.

During one of the communications sessions, a space television bridge was established, linking the Mission Control Center, the space station and Tokyo. Cosmonaut Training Center Chief Lieutenant-General Shatalov introduced the Soviet-Japanese crews now going through the final stage of preparation for a space mission—Soviet cosmonauts Viktor Afanasyev, Musa Manarov, Anatoliy Artsebarskiy and Sergey Krikalev and Japanese journalists Toehiro Akiyama and Reko Kikuti.

Soviet-Japanese Spaceflight Scheduled 2 Dec

LD2310194690 Moscow TASS in English 1929 GMT 23 Oct 90

[By TASS correspondent Rena Kuznetsova]

[Text] Moscow October 23 TASS—Preparations for a Soviet-Japanese space flight have begun at the Soviet Union's Baykonur launching site, a spokesman for the Soviet Glavkosmos space agency told TASS.

Two Japanese journalists—Toyehiro Akiyama and Rioko Kikuchi of the TBS radio and television network—are preparing for the flight with a soviet crew to the soviet Mir space station at the Cosmonaut Training Center near Moscow.

The take-off is scheduled for December 2.

Aleksey Leonov, deputy head of the Training Center, told TASS that both Japanese contenders for the place in the Soviet spaceship are "self-disciplined and studious."

A Soviet state commission will decide which of the two will fly to Mir on the eve of the flight.

Special pavilions are being built at Baykonur for guests and reporters. The take-off is planned to be broadcast live.

Part of the scientific equipment to be used by the Soviet-Japanese crew during their eight-day mission has already been taken to Mir by an unmanned cargo spacecraft.

Japanese Cosmonauts Introduced, Flight Experiments Described

LD0611101790 Moscow TASS in English 1006 GMT 6 Nov 90

[By TASS correspondent Rena Kuznetsova]

[Text] Moscow November 6 TASS—Soviet-Japanese space crews begin their final comprehensive training today, going through all operations that they will perform in space during an international space expedition to begin on December 2

Two Soviet-Japanese space crews were introduced at the Mission Control Center on November 2. The first crew consists of Soviet cosmonauts Viktor Afanasyev and Musa Manarov and Japanese television journalist Trehiro Akiyama. The other team includes Soviet cosmonauts Anatoliy Artsebarskiy and Sergey Krikalev and Japanese woman journalist Rioko Kikuchi.

"Our Japanese colleague is expected to broadcast a ten-minute television report from the orbital complex Mir every day throughout the eight-day flight. There will be also a 20-minute radio broadcast daily. Both Japanese broadcast journalists have gained wide experience during training on the ground," Afanasyev told TASS.

"This work is very laborious. Therefore the flight engineer of the crew will help the Japanese journalist in space.

"It is also planned to perform a medico-biological experiment to study the effects of zero gravity on cosmonaut's sleep patterns during the adaptation period," Afanasyev said.

"An experiment with frogs, suggested by the Japanese side, is also noteworthy. The experiment will involve an utterly special frog population found in Japan. They differ from the other frogs by having natural [suction] disks that will enable them in principle to fix their position on board the orbital station. It is very interesting to find out how the frogs will behave in weightless conditions," Afanasyev added.

One representative of the TBS television and broadcasting network will work in space. Which crew will go to space will be decided upon by a state commission on the eve of the launch.

Problems With Mir Station Ergonomics, Flight Documentation

907Q0088 Moscow RABOCHAYA TRIBUNA in Russian 30 Mar 90 p 4

[Article by A. Filippov, Zvezdnyy Gorodok: "The Mir Station: What Is Interfering With the Flight"]

[Text] **The state commission arranges such meetings immediately after the crew completes the medical examination after returning to the ground. And the** *Vityazi,* **Aleksandr Viktorenko and Aleksandr Serebrov, were no exceptions, for before being sent to a sanatorium, they had just reported on their flight.**

Thus, it must be noted right off: the fifth main mission to Mir was something of a novelty. What we are talking about is the management under the new economic conditions, in which, like all the rest of the country, the space program must count its money and render an accounting. The final, down-to-the-last-ruble financial total still needs to be tallied. But already, after the first rough estimates, it is clear, Aleksandr Serebrov noted, that the flight was not unprofitable.

Success has been achieved thanks to the results of the 48 science, engineering, and manufacturing experiments, to which 543 communications sessions were devoted. The optimal duration for a stay in orbit has been found—around six months. Over the course of several days, for the first time ever, semiconductor crystals were melted for the electronics industry aboard the spacecraft. The temperature was a record 1,270 degrees Celsius. Grown for several months on Mir were biological crystals needed by medicine, and they contain the hope of humanity for deliverance from AIDS. During the mission, the cosmonauts obtained from orbit the first quantitative data on the ecological situation on our planet. Hard currency was received for an experiment conducted under contract to the American firm, Payload Systems. Lessons were written for school children, which A. Serebrov conducted in his capacity as president of the All-Union Young People's Aerospace Society, Soyuz.

The crew worked 166 days aboard the orbital complex. The length of the workday for every 24 hours amounted not to 8 hours, but rather, at the request of the cosmonauts, to 10-12 hours and sometimes even more. Were all those hours devoted to work? No, as it turns out. And that was a result of design problems.

Because of the station's ergonomic problems, it was not unusual for the cosmonauts to spend as much as 80 percent of the work time ... preparing the work site and fastening themselves to it. This has long been a shortcoming and the need for fasteners along the sides of the station had also been noted by previous crews. But the cart, as the saying goes, still has to be pulled. And each person adapts to the work sites in weightlessness as best he can, displaying at times the marvels of "extragravitational" acrobatics. You photograph the earth

through the viewport and, at the same time, you wrap your legs around something so as not to float away from the viewport at the most crucial moment.

A long-standing problem involves the improvement of the flight documentation. The crews carry with them volumes of reference books and instructions on high-quality paper in a hard binder. The principles for compiling the documentation have not changed since the time of Yu. A. Gagarin's flight. It would seen to be a trifle—the awkward type and placement of the paragraphs or, as journalists say, the layout of the pages in these volumes. But it is precisely such "trifles," it turns out, which cause the cosmonauts to make annoying errors. And there is a large amount of documentation, and some of it, at times, is not used during the flight! These are precious kilograms.

The way out of the situation is the establishment of a single information system aboard Mir in which all the reference documents and instructions for conducting experiments are stored in the memory of the onboard computer. That way the cosmonaut will always be able to call up the needed page on the display screen without any trouble, and it will also be displayed on the screen of the operator in the Flight Control Center.

Some of the problems, as K. Kerimov, chairman of the state commission, noted, should be eliminated within a month. I do hope that this is so. However, not all the deficiencies are being eliminated so quickly. There are good reasons for this, as the representatives of the Energiya scientific production association assured us. Yet, all the same, the crew's position is impressive. They did not leave out a single shortcoming or a single "sharp corner" of the space home.

Development, Functions of Kvant-2 Supplementary Equipment Module

907Q0112 Moscow ZEMLYA I VSELENNAYA in Russian No 3, May-Jun 90 pp 3-11

[Article by M. M. Lemelev, candidate of technical sciences, Energiya Scientific Production Association, under the rubric "The Space Program": "Kvant-2—the Supplementary Equipment Module"; first paragraph is source introduction]

[Text] **In accordance with the outer space research program, a Proton launch vehicle placed the specialized Kvant-2 supplementary equipment module into near-Earth orbit on 26 November 1989. The module docked with the Mir manned complex on 6 December.**

The Birth of Kvant-2

Development of the supplementary equipment module was begun in 1982. At that time, the base unit of the Mir station was already being manufactured. Because of a lack of space, it was decided that the gyrodynes and the new life-support systems complex would be installed not on the base unit, but on a separate space module that could dock with the station. That decision was also the result of the lag noted in the development of those assemblies. Thus, the supplementary equipment module, later called Kvant-2, emerged as a component of the Mir orbital complex.

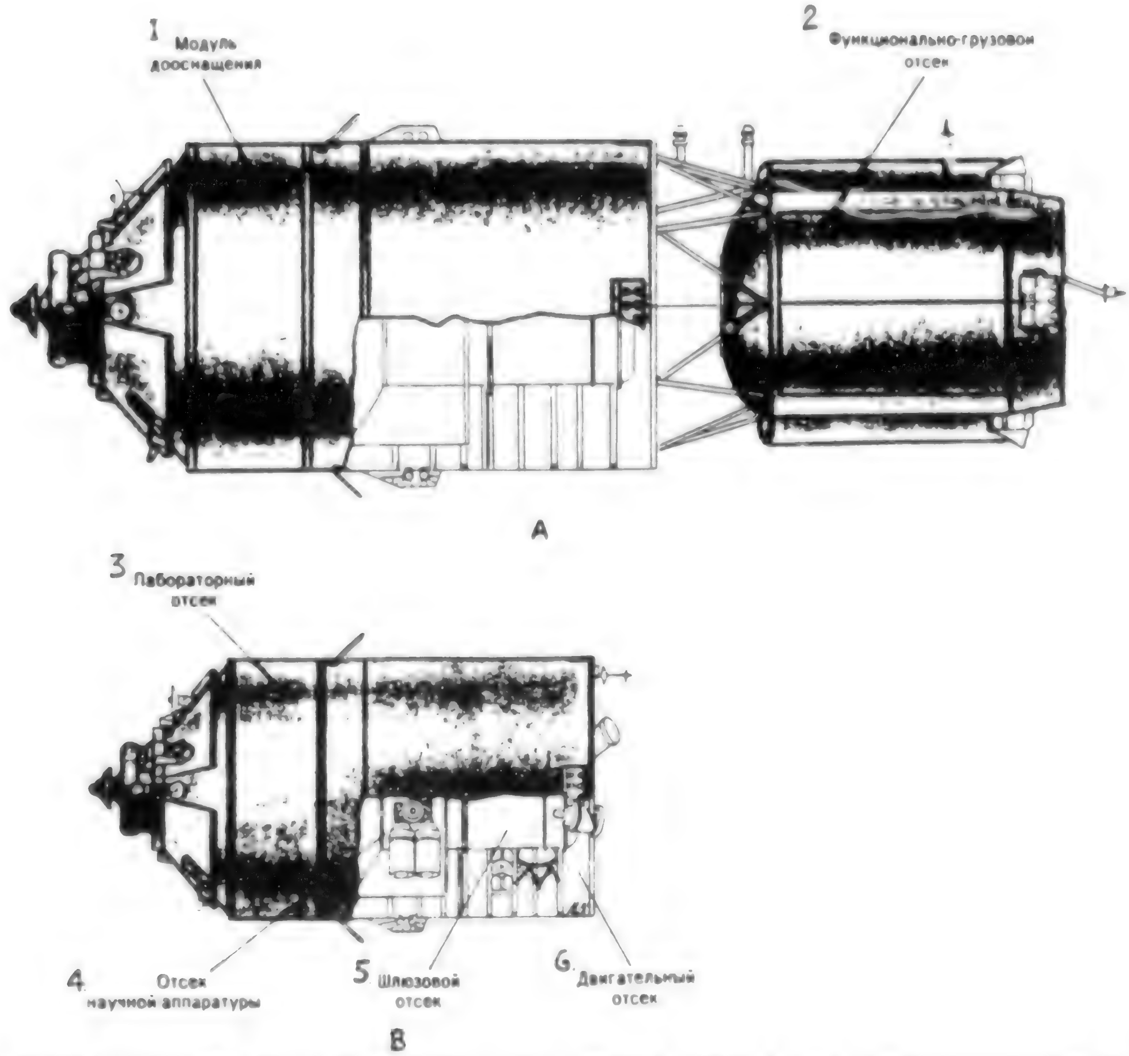
Originally, the general configuration of the main unit that was to be placed into orbit, which included the Kvant-2 as one of its components, was a that of **modular transport craft.** In addition to the module, the main unit included an operations-cargo unit weighing around 10 tons, which was to be used only to effect orbital ascent and docking with the station. In a similar scheme later, the Kvant experimental astrophysical module was delivered to the Mir station (ZEMLYA I VSELENNAYA, 1988, No 5, p 34—*Ed.*). The weight of the payload on the module in that configuration was a little more than 3 tons. Economic analysis showed such a solution to be inadvisable.

A proposed variation was a **"self-propelled" module,** which, after separation from the launch vehicle, could independently effect the necessary maneuvers and dock with the station. A engine compartment appeared for that purpose as part of the module, while it was proposed that control system equipment also be installed in a pressurized compartment, as in the Soyuz-TM transport craft. In that version, the additional weight of the payload on the module was around 5 tons.

There soon emerged one more key decision regarding the design of the module—proposed for use as a base unit was an **operations-cargo unit,** the design of which had already been developed by the producer-plant. It had to be equipped with additional compartments for some of the payload. This variation had a substantial drawback—in order for the module to be able to dock with the station, the basic systems of the operations-cargo unit would have to be modernized, since they had been built on the basis of equipment that, by this time, was obsolete. However, in light of the need for coherence in the design to be used, a final decision was made in mid-1984 in favor of the latter version.

Development was quickly begun of a new control-of-motion system that would provide attitude control and would enable the docking of the module. Its development was subsequently dragged out, which, to a large extent, affected the module's launch dates. Also modernized were the propulsion system, the on-board control systems, and the temperature control system. All these systems were standardized for subsequent Kvant-series modules.

Quite a few problems had to be solved in configuring the module. On the one hand, the design of the operations-cargo unit, which was converted into an **instrument-cargo section,** had to be preserved as much as possible; on the other hand, more than 7 tons of various pieces of equipment had to installed. As a result, two additional sections emerged—an **instrument-science section** and an



The original versions of the design of the supplementary equipment module: A—the modular transport craft; b—the "self-propelled" module.

Key: 1. Supplementary equipment module—2. Operations-cargo section—3. Laboratory section—4. Scientific equipment section—5. Air-lock section—6. Engine compartment

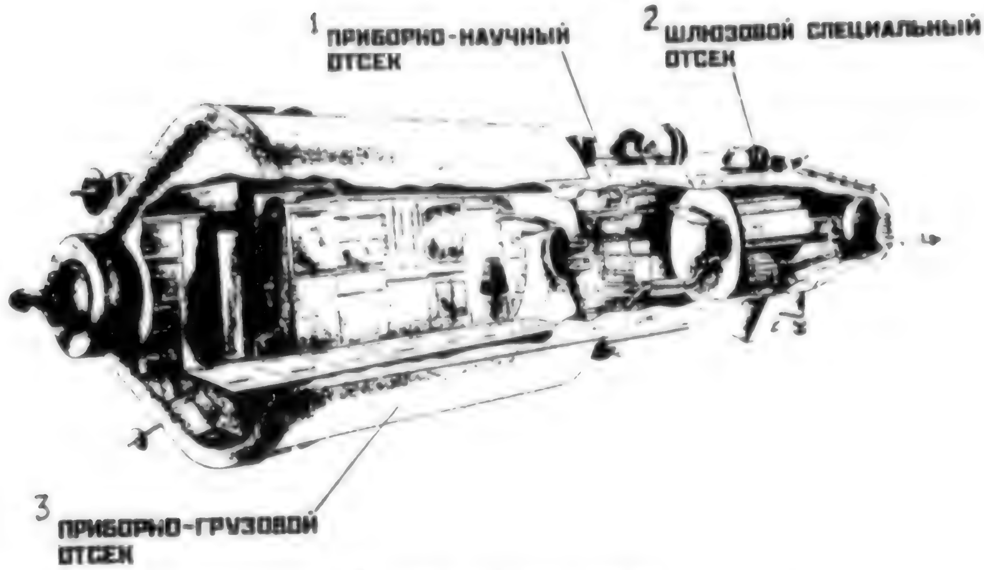
air-lock section. In the end, the Kvant-2 module was more than 12 m long, and its sections had nearly 65 cubic meters of space.

The antennas for the **Kurs automatic rendezvous and docking system** were placed on the conical bottom of the instrument-cargo section. The docking assembly was joined with the bottom by a sealed spacer.

Most of the equipment for controlling the module is located on heavy-duty racks in such a way as to leave the central area clear, so that the equipment can be serviced and individuals can pass through to the instrument-science section.

The research equipment is located primarily in the instrument-science section. Situated in the rhomboid-shaped instrument-cargo section are the control station and the equipment for the systems that ensure the functioning of the Kvant-2 as part of Mir's scientific research complex. The air-lock section is designed to allow the crew to exit into space. Such is the general design of the layout of the supplementary equipment module.

The basis for Kvant-2's control-of-motion system is the **on-board digital computer system.** It ensures the reception, storage and logical processing of the flight tasking and the issuance of that tasking in the form of command signals to the associated systems and to the actuators. When, after the module's launch, the hinges on one of the two solar arrays did not open, it was the craft's digital computer system that provided the flexibility to alter the control modes and to ensure the docking of Kvant-2 with the manned Mir complex.



Schematic of Kvant-2 module

Key: 1. Instrument-science section—2. Special air-lock section—3. Instrument-cargo section

The Experimental Laboratory

After the Kvant-2 module docked with the Mir station, a fundamentally new operation was performed that involved the transfer of the module to an outward-facing docking port in order to free the station's axial docking position. Even in weightlessness, the performance of such dynamic operations in orbit is not at all a simple matter, in light of the substantial mass-inertia characteristics of the bodies being moved.

A special manipulator arm was developed that operates according to a rigid cyclogram. It is mounted on the docking assembly. First, the module's docking rod moved the module 15 cm away from the station. Then a command was given to the electric drive, and the manipulator arm grasped the socket on the base unit. Then, after withdrawal of the rod's head out of the station's docking device, the manipulator arm made several turns of the module relative to the orbital complex. As a result, the 20-ton Kvant-2 ended up opposite the cone of the station's lateral docking assembly. The module's docking rod was again extended, and the process of a hermetic docking was repeated. The transfer took about an hour.

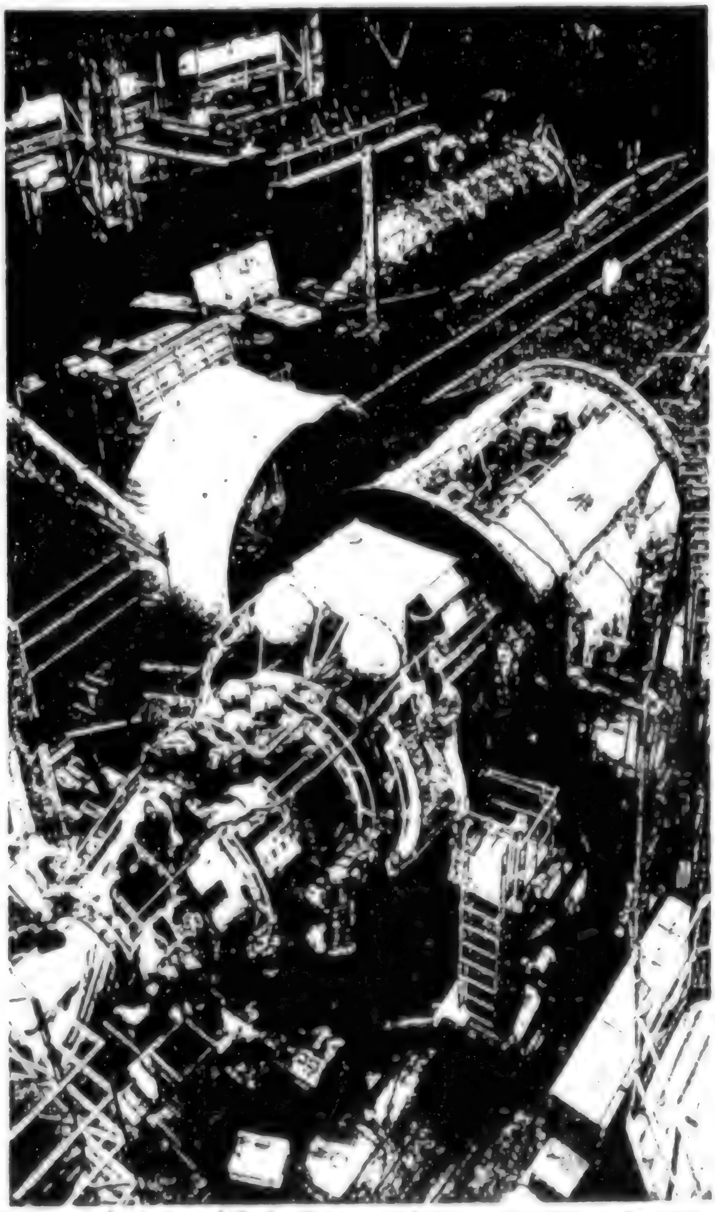
After the transfer, some of the module's systems that had been in operation during the independent leg of the flight were shut down. However, others continued to operate, not only ensuring the use of the module itself, but also enhancing the efficiency of the operation of the orbital complex as a whole.

That also pertains to the module's propulsion system. In contrast to those of the station, Kvant-2's four fuel tanks and the assemblies and the fixtures of the propulsion system are not located in a special compartment—they are located on the module's exterior. Two sustainer engines with a thrust of more than 400 kg each were used during the orbital correction. Two bands of 40-kg thrusters on the instrument-cargo section and the air-lock section are intended for attitude control and control of coordinate positioning during the module's rendezvous with the station.

It was originally proposed that the module's residual fuel be pumped from its tanks (approximately 600 kg) into the station's propulsion system with a special line. However, later it became necessary to abandon that idea and use the fuel on the module itself. The attitude-control engines of the module and the station were consolidated into a single system. That was a necessary measure resulting from the need to orient a multi-unit complex that changes its geometry after each new module docks with the station.

All the basic systems of the supplementary equipment module and the station were linked. Provision was made for creation of a single "central heating plant" formed by the appropriate hydraulic lines of the temperature control systems of the station and the module. The fact is that with time, the characteristics of the radiator that removes the heat from the station has been deteriorating. The radiator's shield may have been damaged by meteor particles. The merging of the circuits will make it possible to use the module's radiator for the station's needs.

With the arrival of the Kvant-2 module, the cosmonauts' working and living conditions on the Mir station are markedly improved. They now have at their disposal a permanent shower stall and a wash basin, the water for which is purified and recirculated in a special device. Of

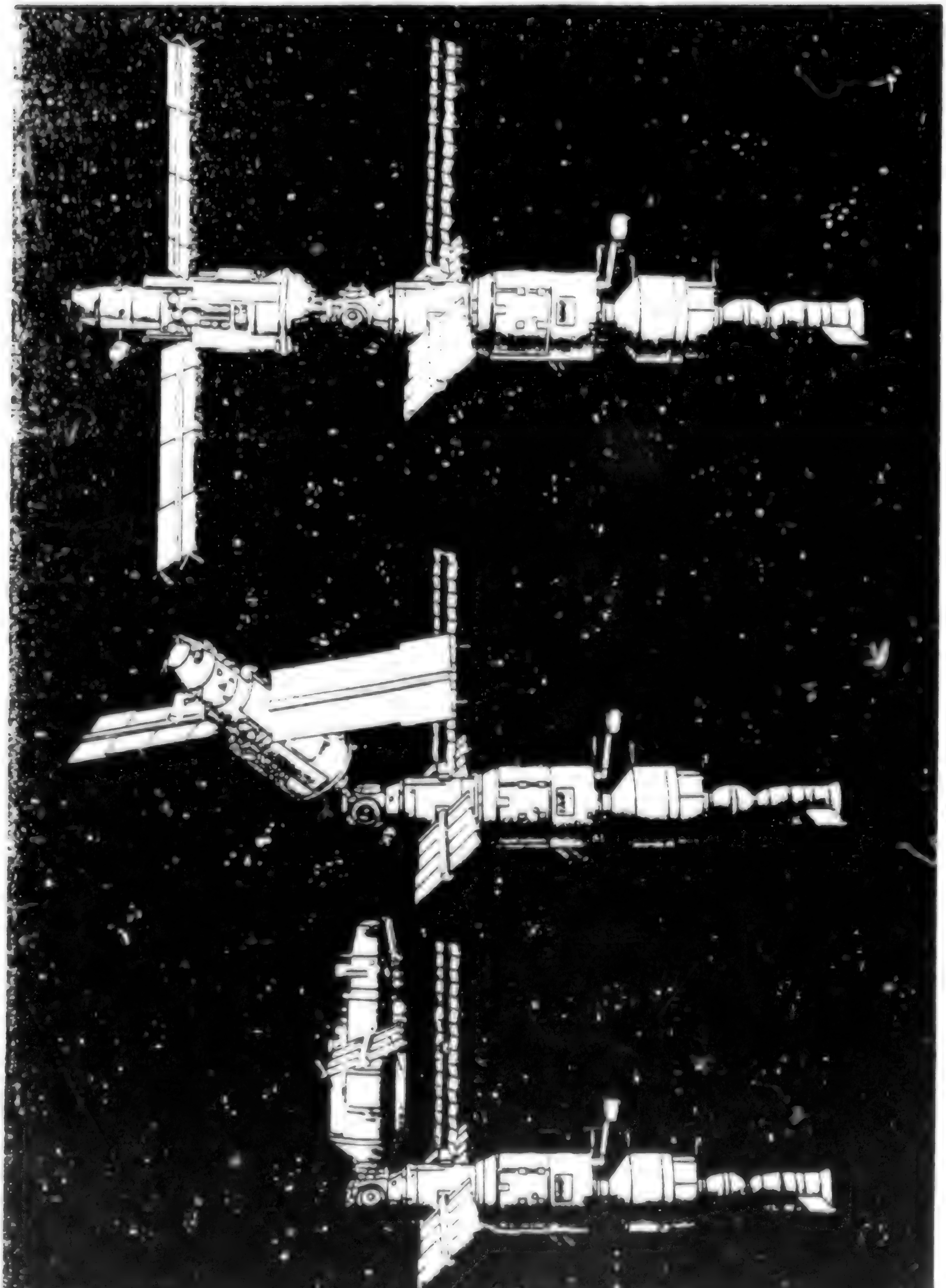


The Kvant-2 supplementary equipment module in the cosmodrome's assembly-and-testing building (TASS photo)

course, we should not delude ourselves: our achievements in this respect are still modest. But what has been done represents an important step on the road to the development of closed-loop life-support systems.

The set of systems for producing oxygen from the liquid wastes of human activities underwent testing on the ground for a long time. It must be noted that the use of these systems promises large savings. Daily, one individual aboard the station needs around 10 kg of expendable stores for vital functions. That, in large part, determines the interval between launches the Progress cargo craft to resupply the station.

Another reason for the regular launches of the cargo craft to the station is the need to replenish the fuel supply. Already installed on the Kvant module are rapidly rotating "tops"—gyrodynes that effect attitude control of the orbital complex with virtually no expenditure of fuel. But, with the increase in the mass and moments of inertia of the Mir station, an additional set of gyrodynes was needed. That set is located on the exterior of the Kvant-2 module's instrument-science section, and it made it possible to free up the pressurized area for the installation of a variety of equipment and to improve the gyrodynes' operating conditions (in sealed housings which have to be provided with a specific degree of vacuum).



The transfer of the Kvant-2 module from the axial docking port to a lateral port on the Mir station's transfer module

The regular use of the Kvant-2 module's life-support systems, gyrodynes and a number of other units requires considerable power consumption. Meanwhile, over the course of time, the photovoltaic cells on the Mir station's solar array panels have been deteriorating. In light of that, one of the basic tasks of the Kvant-2 module is to supplement the Mir station's power supply system. The output capacity of the Kvant-2's power supply system is more than 6 kW.

Solar array panels with drives for their independent alignment are located on the instrument-science section, and chemical sources with automatic units that effect the "output" of a constant stabilized voltage to the consuming units are located in the instrument-cargo section. When one of the panels on the Kvant-2 module did not open fully, a rather critical situation developed with regard to the power balance of its systems. A series of attempts were made, in conjunction with dynamic operations, to actuate the electric drives for the unopened hinges and the drive for the aiming of the entire panel. As a result, the panel opened up completely, and, after docking, the Kvant was able to feed the station the electric power it needed.

The power supply systems of the module and the station formed a consolidated electrical network for the orbital complex. All the array panels of the module and the station are tracking the sun via signals of sensors that have also been consolidated into a single system.

All these design solutions were, for all practical purposes, firsts. They will serve as the basis for the functional design of the on-board systems of future multi-unit orbital complexes.

For Work in Open Space

More and more often, cosmonauts need to work in open space. Located in the Kvant-2's air-lock section and intended for such work are two self-contained space suits and the **unit for maneuvering a cosmonaut in free space (MMU)** (ZEMLYA I VSELENNAYA, 1982, No 3, p 31—*Ed.*).

The air-lock section is equipped with pressure-regulating equipment, a control console, special securing devices and other equipment. The geometric shape and size of the air-lock section are similar to those of the Salyut-7 station's transfer module. So that maximum use can be made of the section, it is the first such section to have a hatch that opens outward. The diameter of the entry hatch is 1 m (the diameter of the station's entry hatch is 0.8 m). So that the hatch can be tightly sealed (a force of around a ton created by the pressure in the section acts on it), locks that open up with an easy turn of a handwheel had to be developed.

When exiting from the Kvant-2 module's air-lock section, cosmonauts A. Viktorenko and A. Serebrov used the self-contained space suits that are not connected with the station by an electric line. The transmission of telemetry information to Earth and radio conversations went through a unit installed on the space suit. Medical parameters were monitored with the compact Beta-8 equipment, which is also located on the space suit. The life-support equipment and the power sources enable up to 5 hours of independent work by an individual in space.

For the cosmonaut's movement outside the Mir station, there are rows of handrails on its surface and there are various securing devices. But that means that the cosmonaut can move toward specific areas only. However, the need sometimes arises to perform inspection or repairs in other areas. For example, on the Kvant module, the cosmonauts had to replace the x-ray telescope unit. Getting to the repair site in an inflated space suit not only requires large expenditures of a cosmonaut's energy, but may also result in damage to the shell of the pressurized suit by structural members.

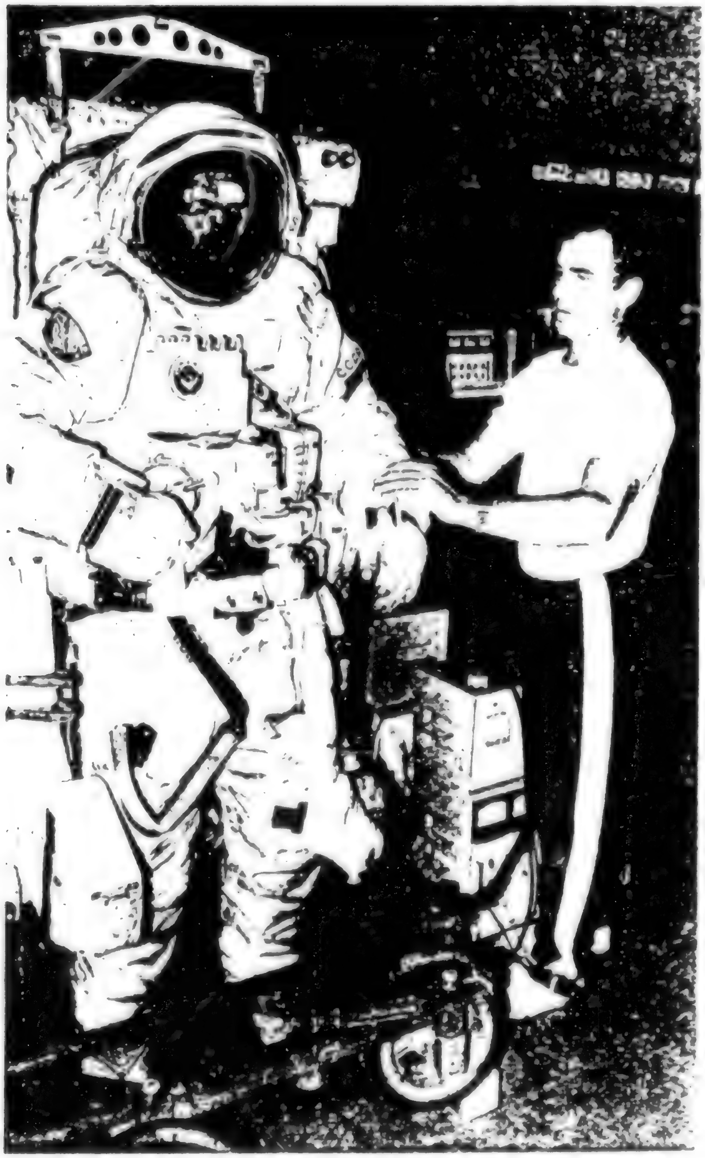
Several years ago, the American astronauts tested an MMU that made it possible to fly short distances. Now, such a "space motorcycle" has also been tested by our cosmonauts. Using the MMU's hand controllers, the cosmonaut determines the direction of movement in space. The movement is effected by thrusters that operate on compressed gas, the supplies of which are adequate for repeated moves spanning tens of meters. The MMU's frame has a bracket for attaching loads of up to 50 kg and transporting them.

The cosmonaut is tethered to the station by a safety winch that automatically takes up the line's slack. However, the line hinders the maneuvers. It is likely that, in the future, the MMU will have to be modernized so that, if need be, it can be controlled from the station.

The Volume of Research Is Being Expanded

After the docking of the Kvant-2 module to the station, the dimensions of the orbital complex exceeded those of a ten-story building. Controlling its attitude in space requires considerable power expenditure. And for many experiments, it is important that the equipment have a specific orientation with respect to the target of study. That is why observation time is cut back and carefully distributed among the various scientific programs. With the arrival of subsequent modules, that situation will become even more acute.

The way out of the situation that has developed is to place the research equipment on separate steerable platforms. That has already been done on the Kvant-2. On the exterior of the instrument-science section, on an automated steerable platform, is a **television videospectral complex**, which includes black-and-white and color television cameras and multichannel spectrometers for the study of the atmosphere and underlying surface of the Earth. Also located there is the **ARIZ x-ray radiation**



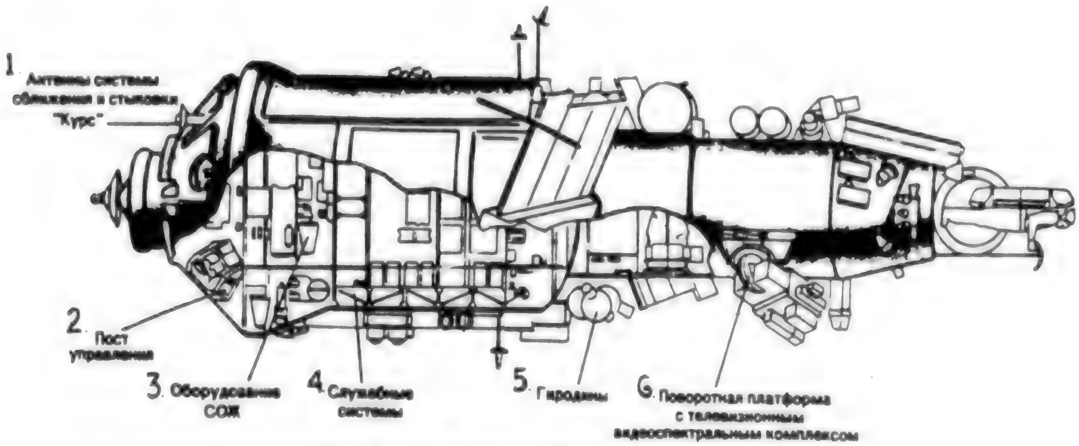
Flight Engineer A. A. Serebrov with the manned maneuvering unit and, next to him, the crew commander, A. S. Viktorenko (TASS photo)

analyzer. In addition, a sealed unit with an additional color television camera is mounted on the platform for cosmonaut EVAs.

The **automatic stabilized plaform** is a manipulator arm that weighs more than 100 kg and has two electric drives that can perform rotations in two planes and can effect precise pointing of the frame that holds the instruments. The platform appeared on the supplementary equipment module after the work on the VEGA project. Soviet and Czechoslovakian specialists had developed steerable platforms, one of which was not used. Development of the many structural assemblies and the automatic equipment for the platform was completed within tight time frames, and it was installed on the supplementary equipment module. The angular rate of the platform's rotation is 3°/min, and the guaranteed useful life for its operation has been increased.

The instrument-science section is equipped with a work station for the cosmonaut's work with the TV videospectral system. Located there are the controls, a screen on which the incoming information is displayed, and video recording equipment that provides for the transmission of an image obtained outside the station's line-of-sight area with ground stations.

The platform can be controlled on a real-time basis from the ground as well. A special on-board processor in the



Placement of the equipment on the Kvant-2 module

Key: 1. Antennas of Kurs rendezvous and docking system—2. Control post—3. Life-support equipment—4. Service systems—5. Gyrodynes—6. Steerable platform with television videospectral system

Kvant-2 instantaneously reads the incoming commands, which, after conversion, are fed to the platform's drives in the form of control signals. The television image, which fixes the frame of reference of the object being observed, and the telemetry information are sent to the Flight Control Center via regular communications channels. That makes it possible for the specialists on the ground to control the platform, when need be, by themselves, without the cosmonauts, and to obtain and evaluate the information rapidly.

In addition, the control system for the Sigma videospectral system is capable of using the information from the star and sun trackers to aim the equipment automatically at a specific region of the celestial sphere. Such an operating mode is used, for example, during astrophysical experiments with the ARIZ x-ray spectrometer.

Steerable platforms with special-purpose equipment can substantially increase the pace of research on space stations. Preventive maintenance and necessary equipment repair by the crew will make it possible to carry out this research for many years.

Among the operations planned for the Kvant-2, a special place has been given to environmental monitoring. Along with the television cameras, the **Gemma-2 video/spectropolarimetric system** is intended to do such work; it records the spectral and energy characteristics of the sites under study. It consists of a self-contained optical receiver unit and an on-board computer and data-processing system. The receiver unit is installed inflight on an unused viewport in the instrument-science section by a cosmonaut. The information obtained goes through instant analysis aboard the module and is displayed on a color graphics display. Then the recorded spectra are transmitted to the ground for further processing. In order to get a photographic frame of reference for the regions under study, the **KAP-350** device, which produces high-quality photographs, is installed on a viewport in the air-lock section.

The **Faza equipment**, installed on the outside of the instrument-science section, is used in atmospheric research together with the TV videospectral system.

Traditionally, biological research is conducted on orbital stations. Installed in the instrument-science section for the study of embryogenesis and the special features of the development of living organisms is the biological **Inkubator-2 system,** which was developed jointly with Czechoslovakian specialists. The goal of the experiments is to produce data on the effects of space flight factors on heredity. A Japanese quail was selected as the research subject. On a manned facility, such experiments require special measures for removing harmful impurities and odors and for preventing them from getting into the atmosphere of the inhabited quarters. The biological system has its own life-support system. The duration of the experiment is around four months. The length of the incubation cycle is three weeks.

The list of applied technical experiments is varied. In order to test the capillary devices for extracting liquid from the fuel tanks in weightlessness, there is the **Volna-2 system,** which consists of a hydraulic stand, a control console and removable models of the capillary devices. It is assembled by the cosmonauts in the instrument-cargo section of the supplementary equipment module. It weighs a total of around 250 kg. The experiment's results are recorded on movie film.

The **Astro optoelectronic system,** developed by specialists from the GDR and the USSR, goes through an experimental check as part of the control system. It is based on the S1 optical unit, which consists of three measuring channels and is installed on a temperature-controlled plate on the outside of the air-lock section. The accuracy of the frame of reference to the star system amounts, in all, to several seconds of arc.

Replaceable panels with test pieces installed on the outside near the air-lock section's exit hatch will help to

answer the question about how space flight factors affect composite materials and the condition of the radiators of the temperature-control system and the vacuum screen insulation

The **ERE equipment** will make it possible to to evaluate the state of electronic and radio elements in a vacuum. The information is recorded in the course of the experiment in a memory unit, and it is then relayed to the module's on-board measurements equipment.

A general-purpose platform on the air-lock section is used for mounting of the replaceable test samples during a crew EVA. Experiments are conducted on this platform **using the Danko and Ferrit equipment**, which will assist in finding out how the structure of prospective structural materials changes.

The large amount of the equipment on the Kvant-2 has made the crew's work more stressful, and the servicing of the systems of the multi-unit orbital complex also requires a great deal of effort. If the crew is to be expanded, new and unusual solutions, necessary for the development of future space complexes, will be needed.

Survey of USSR, World Space Programs

1989 Space Programs

907Q0090A Moscow POISK in Russian No 14, 7-13 Apr 90 pp 4-5

[Article by Mikhail Tarasenko, candidate of physical and mathematical sciences, scientific associate of the Moscow Physical Technical Institute and permanent head of the "Space Chronicle" section in MFTI's large-circulation newspaper ZA NAUKU, under the rubric "POISK File": "Our Dear Satellites"; first three paragraphs are source introduction]

[Text] **In speaking at the annual General Assembly of the USSR Academy of Sciences, Academician Konstantin Frolov, vice president of the USSR Academy of Sciences, talked about the need to have the "concept of common sense in space research."**

But the debates which have recently flared up about the role and substance of the national space program lack, in our opinion, comprehensive and objective information. Although glasnost has, indeed, removed many prohibitions, even a well-prepared reader has trouble piecing together for himself a more or less complete picture of the state of affairs "in our space" and comparing it with the world level and evaluating it from the standpoint of need.

This survey will help in that matter. It was prepared by Mikhail Tarasenko, candidate of physical and mathematical sciences, scientific associate of the Moscow Physical Technical Institute [MFTI] and permanent head of the "Space Chronicle" section in the MFTI large-circulation newspaper ZA NAUKU.

In 1989, throughout the world, 102 launch vehicles placed 136 satellites and two interplanetary stations into orbit. The Plesetsk Cosmodrome was used most often. Launches were also conducted from the following cosmodromes: Baykonur (Tyuratam), the U.S. eastern and western launch complexes, the French Kourou facility, and the Japanese Uchinoura and Tanegashima complexes.

Country	Space Budget	LVs Launched	Spacecraft Launched
USSR	6.9 Billion Rubles	74	100
United States	$29.6 Billion	19	26
Arianespace (Western Europe)	Approx. $600 Million	7	10
Japan	$960 Million	2	2

In comparison with 1988, the number of launches in the USSR decreased, while those in the United States increased. As paradoxical as it may seem, both those trends may be considered positive ones. In the United States, the consequences of the 1986-1987 accidents have been overcome, while, in the USSR, the "short-lived" photographic satellites have been replaced by vehicles with a longer active life. However, this year, 1990, the number of launches decrease again, because of a reduction in allocations by 10 percent.

In the past year, there were five launches in the United States of the Space Shuttle craft, with the participation of 24 astronauts. The December mission with the Hubble Space Telescope has been shifted to 1990.

One manned craft was launched in the USSR in 1989 (there were three in 1988). The reason for the reduction in the number of launches is the continual delays in the readiness of the new modules for the Mir complex. Because of that, it was even necessary in April to interrupt the manned operation of the complex.

It had originally been planned that the assembly of the Mir complex would be completed during the current five-year plan, and the 100-ton Mir-2 base unit was scheduled to be launched in 1992 to replace it. But, if the deployment of the complex continues at the current pace, then the base unit's useful life may expire before it is completely outfitted with all five modules.

The experience of the Mir complex is, obviously, also having an effect on the fate of the American modular-type station, Freedom. Because of budget limitations, Freedom's design has already repeatedly been simplified, and, in order to reduce the cost of the program, Canada, Japan and Europe have been brought into it. The reduction in appropriations from $2 billion to $1.8 billion forced NASA to work up a routine "scaled-down" version of the station, sarcastically called "Nonentity-89."

In contrast to the "bumper crop" of international missions in 1988, there was not a single such mission in 1989. None is scheduled for 1990. But in 1991, the Mir station is to receive cosmonauts from England (in March-July), Japan (in May), and Austria (in November).

In 1989, the United States began launching two new launch vehicles, the Delta-2 and the Titan-4, which were developed on contracts from the U.S. Department of Defense. The Delta-2 was developed especially for launches of the Navstar system's navigation satellites. Eight such rockets can be produced in a year, and since only six Navstars need to be launched per year, the "surplus vehicles" will apparently be used for launching commercial payloads. The Titan-4 has been developed as an alternative launch vehicle, and because of it, the Defense Department could, as of 1992, abandon launching military satellites with the "shuttles."

The Soviet Energiya-Buran transport system was not used in 1989 and, apparently, will not be used in 1990. In any case, the program promised more than a year ago for its use has still not been made public. The lack of Energiya launches stems from their high cost and a lack of payloads.

It should be said that NASA is failing to obtain appropriations for the development of the heavy-lift Shuttle-C launch vehicle, which is similar to Energiya, because the U.S. Department of Defense "does not feel the need for such a launch vehicle." For the time being, the only potential cargo for the Shuttle-C consists of the larged units of the Freedom orbital station (and its fate has already been mentioned above). That is why, judging from everything, the USSR's offer to deliver a 100-ton cargo into orbit for any customer is hardly evoking a response, and the third Energiya launch will, evidently, involve further flight tests of Buran in 1991.

Buran's third flight in 1992 will be a manned one, while its flight design tests, in the opinion of "chief pilot" Igor Volk, will be completed no earlier than 1994.

The experience of the Space Shuttle is showing that putting a system into operation does not remove the need for outlays for getting the bugs out. Since 1981, some $2.4 billion have been spent on modifications of the Space Shuttle's components, and that is more than was spent to construct the new Endeavor orbital craft to replace the lost Challenger. And an additional $1 billion was spent on modifying the craft after the Challenger accident.

Despite all those expenditures, NASA specialists estimate the probability of the loss of an orbital craft at 1 in 78 for a single launch. (The probability of a crew perishing is somewhat less). That means that there is a better than 50 percent chance that one of the existing craft will be lost before 1995 (a total of 68 flights are planned for that period). That is why NASA considers it expedient that funds be appropriated for the construction of not one, but two new orbital units.

Other countries are working on the development of their own space transport systems. In Japan, four scaled-down copies of the promising N-2 rocket have completed flight tests successfully. In the PRC, three new versions of launch vehicles are being developed. One of them, the Changzheng-2E, will be able to place 8.8 tons into a low orbit. The preparations for manned flights in China are being held up by financial difficulties.

An important moment came in March of 1989, when the first commercial launch of a private launch vehicle took place. The seven minutes of microgravitation brought the Space Services company $1 million, which was paid to it by NASA for the flight with a 286-kilogram payload. A similar attempt by the American Rockets company ended in failure—both the launch vehicle and the cargo were destroyed during the launch.

The winged Pegasus rocket may be the novelty of the year. It is launched from a B-52 bomber at an altitude of 12 kilometers and is capable of placing a 400-kilogram load into a low orbit. However, the Pegasus' orbital launch has been postponed until 1990.

In almost every report about the launch of a routine satellite, mention is made of the "continuation of the scientific investigation of outer space." However, over the entire year, only nine specialized science vehicles were launched throughout the world.

The Soviet Interkosmos-24, the Czechoslovakian Magion-2 satellite, and the Japanese Akebono were designed to study the Earth's ionosphere.

Three satellites have been launched for astronomical and astrophysical research. The Western European Hipparcus is supposed to compile a star catalog. The American COBE satellite is intended to be used for mapping the cosmic background radiation and thus testing existing theories of the origin of the universe. The Soviet Granat, equipped with the French Sigma x-ray telescope and a set of instruments manufactured jointly with Bulgaria and Denmark, is a recent craft based on the second-generation Venera stations.

The September flight of the Bion-9 biosatellite lasted two weeks. The experimentation with monkeys, which has been conducted on Bion satellites since 1983, is aimed at studying the adaptation of higher animals to weightlessness. The goal of the program is to mitigate the severity of this process for the cosmonauts.

The fifth Foton-type satellite is intended to be used for experiments on space-based materials science. In addition to the Soviet equipment, it is also outfitted with French equipment.

But the most exotic type of space research is, perhaps, flight to other planets. Unfortunately, the program for the study of the Martian satellite Phobos by Soviet automatic stations failed. The first Fobos was lost while still on the way to Mars, and communications with the second broke down shortly before it was to rendezvous with Fobos and drop scientific probes onto it.

The American Magellan and Galileo stations, launched in May and October, will not begin basic research for some time. Thus, the only craft which was engaged in the investigation of the planets in 1989 was the American Voyager-2 craft, which did a flyby of Neptune in August.

The so-called applied satellites are producing a maximum of practical benefit with a minimum of fuss.

The meteorological vehicles were represented in 1989 by the Soviet Meteor-2 and Meteor-3, the Japanese Himawari-4, and the Western European MOP-1.

In 1989, the USSR launched the first five Resurs-type satellites for the purpose of mapping and studying natural resources. Just like their predecessor Kosmos series, the Resurs satellites are based on the Vostok spacecraft.

but in the recovery vehicle, instead of a cosmonaut, there is a camera. Almost at the same time, the USSR and the United States began the deployment of navigation satellite systems—the GLONASS and Navstar systems. In 1989, five Navstar and two pairs of GLONASS satellites were launched. In their final forms, each system will consist of 21 satellites in circular orbits at an altitude of around 20,000 kilometers. The American system will be fully deployed by 1992, and the Soviet system, by 1995. For the time being, use of the Tsikada system is continuing in the USSR.

The most numerous family of space vehicles consists of the communications satellites. Last year in the USSR, two each of the Molniya-1, Molniya-2 and Raduga satellites were launched, as were three Gorizont satellites. The same number were launched abroad. Determining their affiliation by country is difficult because of the international integration of space research.

If, in the West, the applied use of space technology has been set up to a large extent on a commercial basis, the USSR did not take the first steps in this direction until 1985, when Glavkosmos was created. In 1988, in order to break into the world market, Glavkosmos sold the rights to the commercial use of Soviet rocket-and-space equipment in the West to the American company, Space Commerce Corporation. However, the U.S. administration's ban on the export to the USSR of satellites with American components has made it impossible so far to launch a single foreign craft, despite the relatively low cost of Soviet launch vehicles. As of yet, we have been unable to export the Soviet Tsiklon rockets for launch from U.S. territory.

That is why the commercial launches of individual instruments and units on Soviet vehicles, plus flights by foreign cosmonauts, appear to be more promising. For example, the French Sifar unit installed on the Foton-5 brought Glavkosmos 1.5 million francs.

It should be noted that foreign partners are trying to pay for the cost of the flights not in money, but rather in scientific equipment and, possibly, in additional shipments of goods. As for the price: $12 million will be paid for the two-week flight by a French cosmonaut.

The objectives of military satellites coincide to a great extent with the purpose of their peaceful brothers: observation of the Earth's surface, weather information, navigation, communications...

In 1989, the United States launched two "unclassified" military satellites and seven secret Defense Department payloads.

In 1989, for the first time, our government disclosed its expenditures for military space programs—3.9 billion rubles out of the 6.9 billion allocated by the budget "for space."

The four small Pion-series satellites, released by the Resurs-F satellites, deserve separate mention. These craft, intended for investigation of the upper layers of the atmosphere, were developed by the student design bureau of the Kuybyshev Aviation Institute. That institute is the second higher educational institution in the USSR (after the Ordzhonikidze Moscow Aviation Institute) to have produced "student" satellites.

Intelligence Satellites

907Q0090B Moscow POISK in Russian No 14, 7-13 Apr 90 p 5

[Article by Academician Boris Raushenbakh, under the rubric, "And Here is the Opinion of Academician Boris Raushenbakh": "Why Do We Need Spies in Space?"]

[Text] I consider our lag behind in space to be relative. In a whole number of areas, we are ahead of the Americans. For example, our cosmonauts have stayed aloft in space for a year, while the American astronauts have not even come close to that length of time. Our country is the only one that is performing in-orbit assembly of a station consisting of modules (Mir). But we are, in fact, behind the United States in the investigation of the solar system's planets. The reason for the lag is the low quality of our electronic equipment. I am talking about production quality, not conceptual quality. In order to perform flights within the solar system, a space vehicle should be able to operate at least for five years, preferably 10-20 years. It is difficult to imagine a Soviet-manufactured television set, for example, that continues to work for 20 years.

Are our allocations for space justified? The notion of immeasurably large expenditures for space is artificial, inasmuch as information about the purposes of a launch is frequently wrong, especially when we are talking about the launches of Cosmos-series satellites. Most of those satellites are not intended for scientific research at all. They are reconnaissance satellites, or, as they are sometimes called, spy satellites. However, the latter is simply not true, since the satellites are not doing anything illegal. They are just carrying out continuous observations of the Earth's surface.

I frequently cite an example which demonstrates the capabilities of the reconnaissance satellites. The United States can't even build a dog kennel without our knowing about it in this country, and vice versa. The satellite flights have made possible the signing of agreements between the USSR and the United States on strategic arms limitations, and the satellites, in fact, are monitoring the observance of the agreements.

I would note that it is impossible to use false reports to conceal the purpose of the launch of a given satellite. Specialists can easily distinguish a research satellite from a reconnaissance satellite from its orbital features (its altitude, period of revolution and so on).

When people demand that funds for space research be cut, they forget about two things. First, in many areas involving the development of space hardware, we are on

a world-class level. It is easy to lose a leading position and much more difficult to catch up. Second, we shouldn't undermine the bases for maintaining peace. Most of the Kosmos-series satellites are used to monitor the observance of the adopted agreements and are making possible the signing of further agreements, such as those regarding the reduction of strategic rockets by half. Incidentally, in all the agreements signed with the United States, there is a clause which says that monitoring of the observance of the agreement is to be done using the country's own resources. This action which is fundamental for maintaining peace is being done with satellites.

I believe that we shouldn't scrimp on the preservation of a peace which is being kept by the satellites. The reconnaissance satellites represent the peaceful use of space, inasmuch as they do not carry weapons and they serve the cause of peace.

As for the mutual relations between the USSR Academy of Sciences, which is the customer for space technology, and its supplier, the USSR Ministry of General Machine Building, I think that it is necessary to return to the practice which came about after the launch of the first satellite. In S. Korolev's time, a specific scientific objective was set up, and a space vehicle was developed for it. After all, the vehicle's appearance changes greatly in relation to the task. The Academy of Sciences should not order space vehicles—it should formulate two or three scientific objectives and, together with the equipment developers, create the space vehicles for them. In any case, the USSR Academy of Sciences should develope its preliminary plans together with industry.

RT-70 Radioastronomy Observatory in Uzbekistan

907Q0114 Moscow ZEMLYA I VSELENNAYA in Russian No 3, May-Jun 90 pp 27-32

[Article by Candidate of Physical and Mathematical Sciences L. M. Gindilis, State Astronomical Institute imeni P. K. Shternberg, Moscow State University, under the rubric "Observatories and Institutes": "Radioastronomy Observatory Under Construction"; first paragraph is source introduction]

[Text] **A radioastronomy observatory of the Astronomical and Space Center of the USSR Academy of Sciences Institute of Physics imeni Lebedev is being built in the mountains of Uzbekistan. Its main instrument will be the largest radio telescope in the world for the very shortest wavelengths. The observatory will operate in the same program with space-based radio telescopes, thereby forming a gigantic interferometric system with dimensions much greater than the diameter of the Earth.**

Deep Into the Millimeter Range

The main instrument in the observatory under construction is the RT-70 radio telescope—a fully rotational, 70-m parabolic reflector that operates in the short, millimeter radiowave range (right down to $\lambda = 1$ mm). Bear in mind that a radio telescope's effectiveness is determined by two main parameters: penetration and resolution. Penetration characterizes the telescope's ability to detect faint objects and is determined by its antenna's collecting area. The larger the reflector diameter, the greater the radio telescope's penetration, the fainter the objects it can detect, and, consequently, the farther into the reaches of the Universe and the depths of time such a radio telescope will be able to penetrate. The angular resolution characterizes the ability to differentiate two objects near each other in a picture plane, or to "see" the fine details of a radio image. The greater the radio telescope's resolution, the more detailed the image that can be obtained. Resolution is determined by the ratio of wavelength to reflector diameter.

The first radio telescopes operated in the meter wavelength range and had a very low resolution. The development of more precise telescopes in the decimeter and centimeter ranges constituted a significant stride forward. One of the first representatives of this class was the Large Pulkovo Radio telescope (LPRT). The largest centimeter-range telescopes are the Arecibo (United States) radio telescope, with its fixed 300-m-diameter dish, and the fully rotational, 100-m radio telescope on Mount Effelsberg (FRG). Any further increase in reflector size for ground-based telescopes comes up against insurmountable problems. First, their costs increase immensely. Second (and this is really the main problem), weight-induced deformations which distort the reflector surface increase. Apparently, the 100-m radio telescope is close to the design limit for ground-based, centimeter-range radio telescopes. Consequently, radioastronomers seek to achieve enhanced resolution by developing systems with excess resolution—variable-profile antennas (LPRT, RATAN-600) and synthetic-aperture, the largest of which is the VLA system in the United States.

Another way of enhancing resolution is to decrease wavelength, that is, to move to the millimeter range of the spectrum. Astronomers have long dreamed of penetrating the millimeter range, not only because of the increased resolution, but also because the mastery of each new range makes it possible to obtain essentially new data about astronomical objects. Optical astronomy gradually broadened its scope of investigations into the ultraviolet and infrared regions of the spectrum. Radioastronomy, which began with meter waves, gradually mastered the decimeter and centimeter ranges and proceeded to studies of the millimeter range. On that path, as it moved to ever shorter waves, radioastronomy not only obtained additional information about already known objects, but also came across new data. Some of it had been predicted theoretically, some came as a complete surprise to the investigators. And in each instance of our mastery of a new range, our knowledge was expanded and enriched.

Why did radioastronomy begin with the meter waves? The reason for this is linked with the development of radio-engineering. For one thing, highly sensitive

receiving equipment appeared in that range before it did in any other. For another, it was in that range that it was easiest to fabricate large antennas, since they did not require a very high degree of precision. As radioengineering mastered new ranges, the highly sensitive receivers appeared—and radio telescopes were developed for those wavelength ranges. In the process, the shorter the wavelength at which observations were conducted, the more precise the reflecting surface had to be.

Producing such a surface entailed considerable difficulties. For that reason, the first millimeter-range radio telescopes were small—they had diameters of but several meters. In the late 1950s, the USSR built the RT-22 radio telescope, which had a 22-m reflector and operated at wavelengths as short as 8 mm (the telescope stands at the radioastronomy station of the Lebedev Institute of Physics, near Pushchino). At the time, it was considered a very large millimeter-range radio telescope, even though it operated near the long-wave boundary of the millimeter range. It continues today to be actively used for radioastronomical investigations, although it has, of course, lost its leading role. In recent years, two large millimeter-range radio telescopes have been built outside the Soviet Union—the radio telescope in the Nobeyama Observatory in Japan, which has a diameter of 45 meters and can operate at wavelengths as short as 3.5 mm, and the West German 30-m radio telescope mounted on Pico Veleta in the Spanish Pyrenees, which operates at wavelengths as short as 1 mm. The RT-70 radio telescope should have higher specifications (D = 70 m, λ_{max} = 1 mm), but achieving that will not be easy.

Selection of the Site

Soviet radioastronomers came up with the idea of building a large millimeter-range radio telescope as early as in the 1970s. A team, that was formed at the Space Research Institute under the direction of Academy of Sciences Corresponding Member N. S. Kardashev undertook a study of the problem.

The first thing that had to be done was to select a site for the future radio telescope. The problem was quite complicated, since the site had to satisfy a multitude of requirements. The first of them was a low geographic latitude, which was necessary if sources in the southern sky, including the center of the galaxy, were to be observed. The second requirement involved a maximum number of clear days per year. This requirement, which is so natural for optical astronomy, was initially not considered obligatory for radioastronomical observatories. However, experience showed that by the time one gets to the centimeter range (even though the radio telescope "sees" through clouds) cloud cover becomes a substantial hindrance that makes it impossible for the radio telescope to attain its maximum sensitivity. This is true to an even greater extent in the millimeter range.

In addition, low humidity was required inasmuch as the absorption of radiowaves in the millimeter range is chiefly caused by water vapor. It was also necessary that the site have a minimum of wind, with negligible temperature gradients over a 24-hour period. Those requirements stem from the need for great precision in maintaining the shape of the reflector surface during operations.

The level of radio interference has to be as low as possible at the site. And finally, economic factors—like the presence of roads, communications, etc.—have to be taken into account.

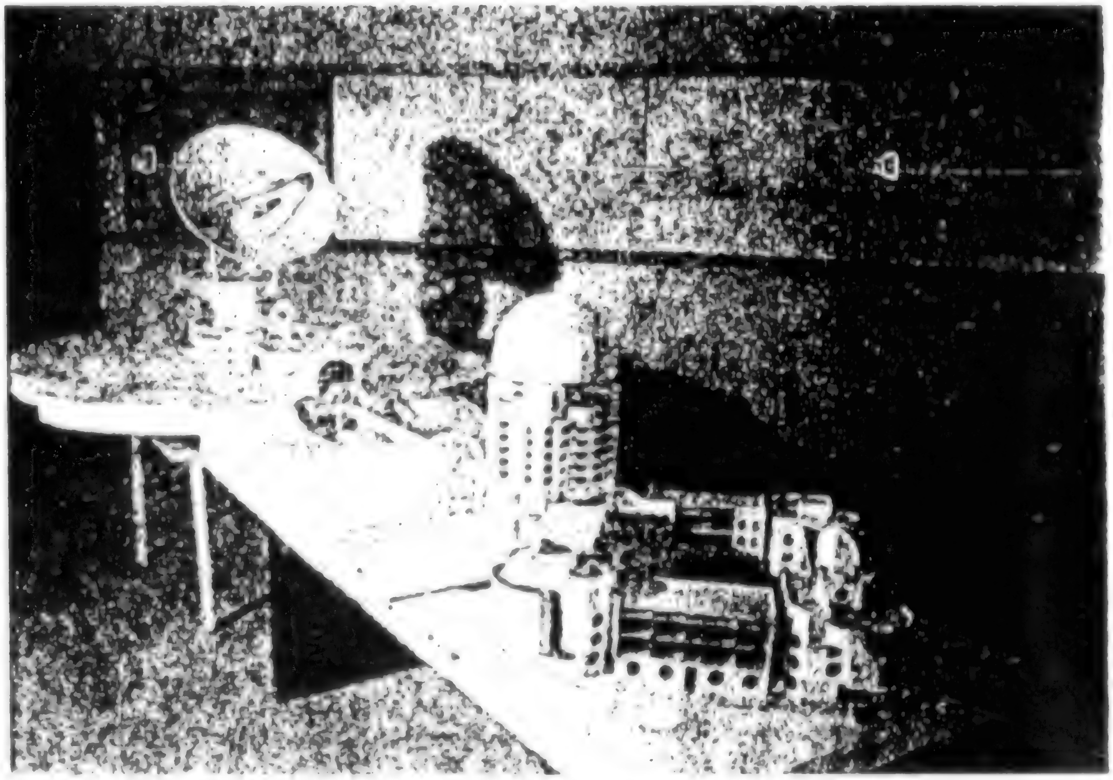
Based on those requirements, the southern regions of the USSR (the Caucasus and Central Asia) were carefully explored for several years. Doctor of Physical and Mathematical Sciences V. I. Slysh was in charge of the investigations. The result was the selection of a site in the Zaaminskiy National Park in the Dzhizak Oblast (now the Syr-Darya Oblast) of the Uzbek SSR—the Suffa (or Suppa) Plateau, which in the Uzbek language means the "flat place." It is situated at an elevation of 2,300 meters above sea level, on the northern slope of the Turkestan Range, between the Pamir and Tyan Shan mountain systems. The nearest large cities are Tashkent (about 220 kilometers to the northeast) and Samarkand (about 150 kilometers to the south).

The plateau, overgrown in places with juniper, is surrounded by deep canyons. The southern horizon is blocked by a snow-peaked mountain chain. To the north and east, the mountains are lower, without snow peaks. The ground is rocky and consists of hard limestones.

In the early 1980s, the site was occupied by a weather station, and regular weather observations were conducted. An expedition of the USSR Academy of Sciences Space Research Institute is also studying radioastronomy climate; the expedition is headed by Ye. F. Rizov.

The RT-70 radioastronomy observatory project was developed at the USSR Academy of Sciences State Institute for the Planning of Scientific Research Institutes, under the direction of A. M. Shchusev, meritorious architect of the RSFSR. The radio observatory consists of the RT-70 radio telescope, the experimental assembly building, the main building, and the power-and-services area. All of the structures run along a north-south line.

The experimental assembly building contains the radio telescope's control unit, calibration benches for regulating the reflecting panels, a cryogenic station, and various engineering services. It is connected with the RT-70 radio telescope's tower by an underground transportation-communication tunnel and with the main building by an aboveground walkway. The main building houses the laboratories, administrative offices, a computer center, a library, a conference hall, a dining room, and a hotel for observers on duty. North of the main building is the power-and-services area, which houses the mechanical workshops, a garage, an electric boiler room, a diesel-powered back-up electric power station, and other facilities.



Model of the RT-70 radioastronomy observatory

The antennas supporting the operation of the RT-70 in the ground-space radio-interferometer configuration are set up at a separate satellite communications site.

Construction of the radio observatory began in 1983, and in 1984 a capsule with a "Message to Our Descendants" was placed in the foundation of the RT-70's tower. It reads as follows:

Dear Friend of the Distant Future:

From deep in the past, 20th-century man addresses you. The message you hold in your hands was placed here in June 1984 to commemorate the beginning of the erection of the RT-70 radio telescope, which was designed to investigate the Universe in the centimeter- and millimeter-wavelength ranges.

Many questions dealing with the structure and evolution of the Universe trouble us. We know that the Universe is expanding, but we do not know whether this expansion will be followed by contraction. We do not know the geometry of the Universe, or the state it was in when it first appeared. We do not know the nature of the galaxy's center or of quasars, and, we must admit, we do not know much about the things that are closest to us. For example, we do not know the nature of comets, or how our Solar System originated, or if there are intelligent beings somewhere on other celestial bodies.

You have new forms of energy that are unknown to us and more precise methods of investigating matter that make it possible to penetrate its innermost depths. You undoubtedly already know the answers to questions that torture us. You yourself are troubled by certain new problems that are unknown to us, and we know that that will always be the case, because development and knowledge are limitless.

Throughout history, man, sensing his unbroken ties with the Universe, has striven to comprehend its laws and has drawn spiritual strength from its beauty and harmony, strength that has elevated man and has led him forward along the road of progress. Centuries separate us, but the same rapture that comes from the beauty of the Universe binds us together.

The cornerstone was laid here today. The years will pass, and on this ancient Earth a magnificent radioastronomy observatory will arise, erected by the selfless labor of Soviet citizens. Today it is still a dream. To bring it to fruition, we need peace on Earth.

You know what mankind went through in the late 20th Century. But you also recall that in those stern times the dawn of a new life, a new world, shone over this great country through the efforts of millions of people who joined the battle under the banner of the great Lenin.

We are confident that reason itself will triumph in that battle. It is difficult for us to imagine even the outlines of

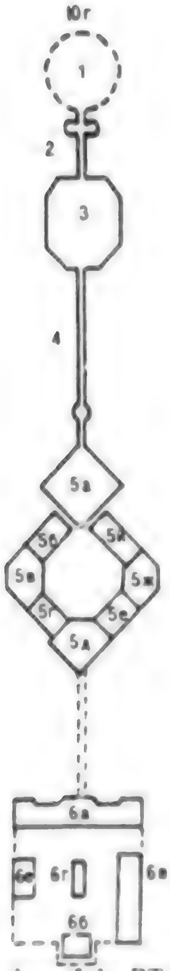


Diagram of physical plant of the RT-70 radioastronomy observatory

Key: 1—RT-70 radio telescope; 2—(not given); 3—experimental assembly building; 4—aboveground walkway; 5—main building; 6—power-and-services area

what is to us the distant future, to you the present. But we want to believe that it will exist. And we believe that it will be beautiful.

Our regards to you, citizen of the Solar System!

In 1988, the construction of the four-story RT-70 tower was, for the most part, completed, and the assembly of the antenna itself was begun. The walls and roof of the experimental assembly building have been completed. Construction of structures in the power-and-services is under way; engineering service lines are being laid. The construction of the radio observatory is entering its most crucial phase. Much work still lies ahead.

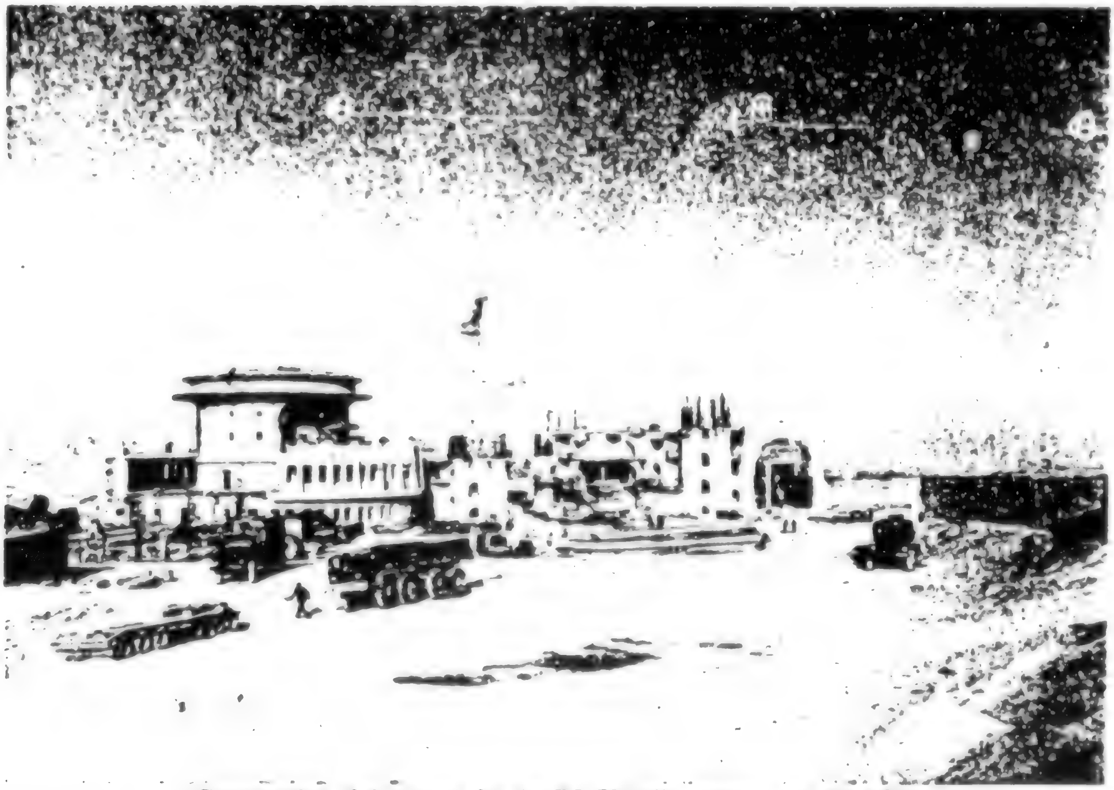
Ground-Space Radio Interferometer

The RT-70 radio telescope will operate in two modes: as an independent instrument, and paired with a space-based radio telescope (SRT), forming with it a ground-space radio interferometer. The creation of such an interferometer is part of the Radioastron project (ZEMLYA I VSELENNAYA, No 1, 1989), a large international project in which many country are involved. The science director for the project is USSR Academy of Sciences Corresponding Member N. S. Kardashev. Let us recall that the first space-based radio telescope—the KRT-10—was put into orbit by the Soviet Union in 1979.

The first stage of the Radioastron project calls for the launch of an SRT with 10-m reflector and a limiting wavelength of 1 cm. The second stage will involve the launch of an SRT of the same dimensions with a limiting wavelength of 1 mm. The telescope will be put into a high-apogee orbit, perpendicular to the plane of the ecliptic (maximum distance from the Earth on the order of 70,000 kilometers). The resolution of the radio interferometer will reach 10^{-5}-10^{-6} seconds of arc.

To support the operation of the RT-70 in the ground-space radio interferometer configuration, the radio observatory on Suffa Plateau will have a special satellite communications complex (see back cover). The complex will have three antennas. Receiving antenna A1 receives the wide-band interferometric signal from the SRT. That signal, when added to the signal coming from the RT-70, creates an interference pattern. Transceiver antenna A2 transmits to the SRT and receives from it the synchronizing signal from the hydrogen frequency standard. And finally, tranceiver antenna A3 provides for radio communications with the Flight Control Center and the Lebedev Institute of Physics Astronomical and Space Center via satellite relay.

The receiving antenna is situated near the RT-70, on the roof of the radio observatory's main building, beneath a radio-transparent housing, while the transceiver antennas are located at the satellite communications site several kilometers from the RT-70. The site chosen uses the terrain around it to provide protection for the RT-70 from the emissions of the transmitters.



Construction of the tower for the RT-70 radio telescope (on the left) and the experimental assembly building (on the right), 1988

Granat Orbital Observatory Working 'Successfully'

LD1210224590 Moscow TASS in English 1803 GMT 12 Oct 90

[Text] Mission Control Center October 12 TASS—The international orbital observatory Granat has already been successfully operating in space for more than ten months.

During the past two months, the observatory has been busy compiling detailed maps of the central part of our galaxy, as seen with the help of x-ray radiation.

An analysis of the data from Granat in the Mission Control Center has resulted in the discovery of three previously unknown x-ray sources that have been named after the observatory—Granat.

X-ray flashes have been registered coming from three other sources in the galaxy center. They were emitted following nuclear explosions on the surface of neutron stars. The nature of these sources has been identified.

The space observatory helps in the search for the neutron star, or black hole, that was expected as a result of the super-nova explosion in the Large Magellanic Cloud. However, no x-ray radiation from this object has been registered.

Measurements continue of the revolution periods of known neutron stars—the Roentgen pulsars. The search continues for sources of gamma-outbursts from space. More than ten such outbursts were detected in September and October.

Granat continues regular observations of solar activity and the radiation background in open interplanetary space and within the boundaries of the Earth's magnetic sphere.

According to telemetric data, all on-board systems and research devices are functioning normally.

'Gamma' Satellite Continues Observations

LD1910222290 Moscow TASS in English 1929 GMT 19 Oct 90

[Text] Mission Control Center October 19 TASS—The Soviet space observatory Gamma, launched on July 11, 1990, continues on its mission. During its 100 days of orbital work, all on-board systems have been thoroughly checked and tested. The search has begun for astrophysical objects which emit bursts of gamma-rays.

Since the end of August, the observatory has been watching the gamma-pulsar in the Sail constellation. High energy radiation has been registered, permitting conclusions to be drawn about the source. The center of our galaxy has been regularly under observation.

The results of tests and checks required certain changes in the research plans. An electric current failure in a Gamma-1 telescope detector network called for reorientating the plan, with most of the work now devoted to gamma-pulsars.

Other work performed by the unmanned observatory is the observation and study of the earth's radiation belts at low altitudes, including in the Brazilian anomaly, and the electron component of space rays. Peak solar activity will be followed as well.

Data from the space observatory is being processed and analysed by scientists in the Soviet Union, France and Poland.

UDC 523.94

Distribution of Radio Brightness at the Solar Poles in the Centimeter Range

907Q0163 Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 67 No 4, Jul-Aug 90 (manuscript received 31 July 1989) pp 845-850

[Article by Ye. G. Kossova, S. P. Leonenko, B. A. Poperechenko, L. V. Yasnov, Leningrad State University]

[Abstract] In the second half of 1983 the Sun was scanned in a linear beam pattern at 5.2 and 8.1 cm in the meridional direction using a TNA-1500 radio telescope. The difference in the dimensions of the Sun at these two wavelengths was found to be -0.006 to -0.055 solar radii with an error of 0.001 solar radii. The increase in antenna temperature at the limb was also measured. When polar brightening was insignificant, the effective dimensions at both wavelengths were similar. The relative brightening of the antenna temperature at the limb varied but did not exceed five percent of the wavelength.

It is shown that a supergranulation model of the upper atmosphere of the Sun does not match radio observations. A two-component model which considers the role of spicules in the absorption of radio waves satisfactorily describes the radio observations of the polar regions of the Sun in the centimeter range. Figures 3; tables 3; references 15: 5 Russian 10 Western.

UDC 523.72

Variations in Hydrodynamic Parameters of Solar Wind Protons and Particles According to Prognoz-7 Measurements

907Q0094A Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 2, Mar-Apr 90 (manuscript received 5 Jan 89) pp 218-225

[Article by Yu. I. Yermolayev, V. V. Stupin, G. N. Zastenker, G. P. Khamitov and I. Kozak]

[Abstract] Systematic selective measurements of the proton and α components of the solar wind by Prognoz-7 (November 1978-July 1979) revealed or confirmed a number of patterns of comparative behavior in hydrodynamic parameters. The relative content of α-particles, when averaged over long intervals, increases somewhat at the maximum of the solar activity cycle. With an increase in solar wind velocity to about 500 km/s from about 300 km/s, the α-particle content, the ratio of α-particle and proton temperatures, and the difference in α-particle and proton velocities increase monotonically. With a further velocity increase, to about 620 km/s, the ratio of α-particle and proton concentrations and the difference in velocities decrease appreciably. The behavior in terms of the difference in velocities can be explained with the hypothesis that fluxes with varying α-particle content mix. The fact that α-particle temperatures are higher than those of the protons is also a function of their relative content, and the difference increases with increasing velocity difference, indicating the important role of frictional forces between the two ionic components. The experiment fully confirmed the presence of a balancing of the transport velocities and kinetic temperatures of different ionic components as a result of exchange of momentum and energy during Coulomb collisions. With an increase in the number of collisions, the gap between measured values for velocity difference and mean values narrows considerably. Figures 6; references 21: 7 Russian, 14 Western.

UDC 581.521

Energy Spectra of Ring Current Ions in Outer Region of Trapped Radiation Zone

907Q0094B Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 2, Mar-Apr 90 (manuscript received 26 Apr 89) pp 226-229

[Article by M. I. Panasyuk]

[Abstract] Experimental data obtained by the Gorizont (1987-07A) and AMPTE/CCE satellites in the outer region of the radiation belts are analyzed on the basis of measurements of H^+, He^{2+}, He^+, O^+ and [C, N, O] ions with a charge greater than or equal to 5^+ and energies greater than 10 keV. The following conclusions were drawn from measurements of the ionic composition of the ring current during a magnetically quiet period in the region of a geostationary orbit. The spectra of H^+, He^{2+} and $[C, N, O]^{5+-8+}$ ions are similar in terms of E/Q for energies greater than tens or hundreds of keV. The relative content of these ionic components is determined by the ratio of the corresponding densities characteristic for the solar wind, thereby confirming the solar nature of these particles. The boundary of the tail of the energy distribution of ionospheric O^+ ions is at an energy level of about 130 keV. Figure 1; references 11: 6 Russian, 5 Western.

UDC 551.521.8

Interkosmos-19 Study of Pulsations of Fluxes of Charged Particles During Magnetic Storms

907Q0094C Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 2, Mar-Apr 90 (manuscript received 23 Jun 89) pp 230-234

[Article by Ye. S. Vinogradova, Yu. V. Mineyev, I. B. Volkov and G. A. Glukhov]

[Abstract] Pulsating fluxes of charged particles usually accompanied by short-period magnetic field fluctuations are observed during magnetic storms in the magnetosphere and ionosphere. The Interkosmos-19 satellite measured charged-particle flux, magnetic field, and VLF emission amplitudes during magnetic storms on 22 March, 3-5 April, and 24-25 April 1979. A Pero-Zl spectrometer was used in measurements of fluxes of electrons with a energies E_e = 0.04-2 MeV and fluxes of protons with a energies E_p = 0.9-8 MeV; a +/-60,000 nT magnetometer was used to measure the magnetic field. The characteristic periods, amplitude and intensity of modulation of particle fluxes were determined for all three events. The characteristics of the pulsations are analyzed as a function of the phase of storm development and the region of their appearance. The results are interpreted on the basis of the hypotheses of exo- and intramagnetospheric origin of such pulsations. Figures 3; references 12: 9 Russian, 3 Western

UDC 551.510.535.2

Influence of Electric Field on Structure of Main Ionospheric Trough

907Q0094D Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 2, Mar-Apr 90 (manuscript received 15 May 89) pp 235-242

[Article by G. Gdalevich, N. Isayev, V. Gubskiy, Ye. Trushkina and G. Stanev]

[Abstract] The influence of an electric field on the structure of the main ionospheric trough (MIT) and on concentration inhomogeneities in the trough region is discussed on the basis of electric-field and plasma-concentration data obtained by the Interkosmos-Bolgariya-1300 satellite in the near-midnight sector of the mid-latitude trough. The possible mechanisms of formation of concentration inhomogeneities in the trough region are examined. Simultaneous satellite measurements included those of electric field, plasma density and particle flux. It was found that the magnetospheric electric field in virtually all cases penetrates into the subauroral ionosphere (beyond the polar wall of the trough). The degree of penetration is dependent on the strength and orientation of the polar wall B_z component of the interplanetary magnetic field (IMF) and on geomagnetic disturbance. The position of the polar wall of the MIT is governed by geomagnetic disturbance and the orientation of the IMF B_z component. The polar wall of the MIT in the near-midnight sector of the mid-latitude trough coincides with the onset of leakage of electrons with a energies of several keV, and therefore it is evident that it is formed under the simultaneous influence of fluxes of leaking electrons and the electric field. The appearance of electron density inhomogeneities in the trough can be attributed to the development of gradient-drift instability. Figures 6; references 17: 6 Russian, 11 Western.

UDC 533.951.2

Small-Scale Ionospheric Inhomogeneities and Features of External Sounding Ionograms

907Q0094E Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 2, Mar-Apr 90 (manuscript received 20 Feb 89) pp 243-247 pp 243-247

[Article by D. S. Bratsun, P. F. Denisenko, N. A. Zabotin, S. A. Pulinets and V. V. Selegey]

[Abstract] A study was made of several aspects of propagation of scattered, slow, extraordinary waves in the range between the local plasma frequency and the frequency of the upper hybrid resonance in the ionospheric resonance layer. The work reported here is a continuation of work previously reported by the authors (GEOMAGNETIZM I AERONOMIYA, Vol 27, p 500, 1987). A numerical analysis was made of the trajectories of scattered waves in the plane of the magnetic meridian on the basis of the collisional absorption mechanism. It was found that at a fixed frequency the waves are focused at a definite altitude regardless of the initial emission conditions. The intensity maximum of scattered waves is observed in the same frequency range. There was a quantitative agreement between theoretical predictions of propagation time and characteristic features, on the one hand, and experimental data collected by the Kosmos-1809 satellite, on the other. This confirms the possibility of direct observation of the process of transformation of an ordinary wave into the z-mode during scattering on small-scale inhomogeneities. It also confirms that natural small-scale electron concentration inhomogeneities exist at altitudes from several hundred to several thousand kilometers. Figures 3; references 7 Russian

UDC 537.591

Model of Dynamics of 'Ionospheric Hole' With Allowance for Processes in Tube of Force

907Q0094F Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 2, Mar-Apr 90 (manuscript received 28 Dec 88) pp 248-254

[Article by M. N. Vlasov, S. A. Ishanov, K. S. Latyshev and V. V. Medvedev]

[Abstract] A mathematical model of the distribution of ionospheric plasma along a tube of force of the geomagnetic field was used in examining the evolution of an ionospheric hole formed by the anthropogenic introduction of water. The behavior of charged particles along a tube of force is modeled by way of the numerical solution of a system of equations of continuity, motion, and energy. The simulation of the influence of the water on the vertical distribution of electron concentration N_e, performed with allowance for processes along a geomagnetic field tube of force, considerably broadens and changes our concepts concerning the dynamics of ionospheric holes. It indicates the particularly important role of ionospheric-plasma exchange under these conditions. It also makes it possible to establish the existence of what appears to be a secondary ionospheric hole during the sunset period and indicates that the effect extends for a far greater time, taking in almost 24 hours, with an important role being played by the dynamics of the forming hydrogen. The ionospheric hole may correspond to an increase in the number of charged particles in the plasmasphere which partially screens the other hemisphere from the effect. However, with a MacIlwain parameter of $L < 3$, such screening is inadequate, and the effects begin to be felt in the other hemisphere. Figures 4; references 8: 6 Russian, 2 Western.

UDC 543.42:522.124

Some Aspects of the Computation of Penetration Function

907Q0094G Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 2, Mar-Apr 90 (manuscript received 28 Feb 89) pp 306-309

[Article by R. A. Nymmik]

[Abstract] The function of penetration of charged particles into near-Earth satellite orbits, $\varepsilon_\Sigma(R)$, is the ratio of the flux of particles with a given rigidity in near-Earth orbits to the flux of particle outside the Earth's magnetosphere. If the $\varepsilon_\Sigma(R)$ is known, one can compute the magnitude of flux of particles outside the magnetosphere from the results of measurements performed in near-Earth orbits, and, conversely, one can find the expected particle fluxes for a given orbit if particle fluxes in interplanetary space are known. In the simplest and most popular instance, $\varepsilon_\Sigma(R)$ is assumed to be equal to δ7 during which a satellite is located in a geomagnetic field region that is accessible to particles with a vertical rigidity R; the angular dependence of the geomagnetic field cutoff rigidity and the effect of the penumbra are disregarded. The author examined the limits of applicability of that method of computation. Penetration function was computed two ways for each of three circular orbits with an altitude 350 km and inclinations of 52°, 62° and 82°. In the first variation, allowances were made for both the penumbra and the angular dependence of cutoff rigidity; both effects were disregarded in the second variation. The computations were made using the Shea-Smart tables of effective vertical cutoff rigidities. The relationship between effective cutoff rigidity and altitude was computed with the formula $R_{eff}(H) = R_{eff}(H = 20)[H_0/(H + H_0)]^2$, in which H was the orbital altitude and H_0 was the Earth's radius in kilometers. Regardless of orbital parameters, the deviations of the results of the simplified computational variation do not exceed 2 percent in a rigidity region less than 7 GV, and they are as high as 10 percent at large rigidities. In cases in which accuracy requirements do not exceed given values, one can disregard the penumbra effect and the cutoff rigidity angular dependence when computing the penetration function, thereby substantially reducing the computer time required for computations. Figures 3; references 3 (Western).

UDC 531.352

Existence of Invariant Tori in Problem of Motion of Satellite With Solar Sail

907Q0094H Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 2, Mar-Apr 90 (manuscript received 11 Jan 89) pp 309-312

[Article by T. A. Rybnikova and D. V. Treshchev]

[Abstract] Nonsmooth Hamiltonians arise in celestial mechanics, such as in the problem of motion of a satellite with a flat solar sail. The A. N. Kolmogorov theorem asserts that most nonresonance invariant tori of a nondegenerate integrable system are preserved when there is a small perturbation of the Hamiltonian, being only slightly deformed. In this paper, the authors formulate a general theorem on applicability of the A. N. Kolmogorov theorem to systems with nonsmooth Hamiltonians, and they apply it to the problem involving the motion of a heliocentric satellite with a flat solar sail. The heliocentric satellite consists of a solid and a plate rigidly connected to each other by a boom that joins the center of mass of the entire system and the geometric center of the plate. The plate—the solar sail—has a surface that is an ideally black body; the sail is positioned perpendicular to the boom. The satellite is referenced to two coordinate systems, making it possible to demonstrate the applicability of the A. N. Kolmogorov theorem to the specific solar sail problem examined. Figure 1; references 8: 7 Russian, 1 Western.

UDC 550.383

Special Features of Biennial Modulation of Galactic Cosmic Rays in Earth's Northern and Southern Hemispheres

907Q0094I Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 2, Mar-Apr 90 (manuscript received 1 Feb 89) pp 312-314

[Article by P. P. Ignatyev and V. P. Okhlopkov]

[Abstract] The biennial period in the modulation of galactic cosmic rays (GCR) and solar activity has long been known as a result of ground-based data. It was first identified in measurements of GCR fluxes in outer space by Gorchakov *et al.* (KOSMICH. ISSLED., 1984, Vol 22, No 3, pp 432-439), who were studying the phase correlations between waves in solar activity and GCR. On the surface, it would seem that such modulation is not magnetospheric or atmospheric. However, research indicates that different energy relationships exist in the temporal variation of two waves of GCR modulation based on measurements in different hemispheres. In fact, biennial variations in GCR at Mirnyy and Murmansk at various isobaric levels show that waves are sometimes synchronous throughout the entire altitude profile of the atmosphere and sometimes undergo a slow phase shift that changes monotonically with altitude of residual atmosphere. The phase fluctuations of the biennial waves are more clearly tracked in a north-south direction. The authors use the rephasing of the magnetic moment of the Sun in 1969-1971 to explain the fluctuations observed here on Earth. Figure 1; references 6: 1 Russian, 5 Western.

UDC 520 6:524.352

Hard X-Ray Radiation from SN 1987A: Results of Observations of the Rentgen Observatory on the Kvant Module in 1987-1989

907Q0104A Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 5, May 90 (manuscript received 26 Feb 1989) pp 403-415

[Article by R. A. Syunyayev, A. S. Kaniovskiy, V. V. Yefremov, S. A. Grebenev, A. V. Kuznetsov, J. Englhauser, S. Doebereiner, V. Pietsch, C. Reppin, I. Truemper, E. Kendziorra, M. Maisack, B. Mony, and R. Staubert, Space Research Institute, USSR Academy of Sciences, Moscow, Institute of Extra-Atmospheric Physics, Max Planck Society, Garshing, West Germany, Astronomical Institute of Tubingen University, West Germany]

[Abstract] The third and fourth detectors of the HEXE experiment were successfully calibrated, and their data increases the confidence and decreases the error of the data of the experiment as a whole. Observations made in June 1989 showed that the 45-105 keV hard X-ray flux from SN 1987A had dropped by a factor of 8.5 from its maximum in January 1988. The hard X-ray light curve makes it possible to determine the distribution of radioactive cobalt in the shell with minimal assumptions. The upper limit of the abundance of $^{57}Co/^{56}Co$ was found to be a factor of 1.5 higher than the Earth's abundance of $^{57}Fe/^{56}Fe$ (at 3σ). Abundances of ^{22}Na and ^{44}Ti were also found. Data is presented to set an upper limit on the luminosity of the stellar remnant, and it is shown that there was strong mixing of cobalt in the early stages of expansion. It is stated that HEXE data can also be used to determine parameters of the hidden pulsar. Figures 6; references 26: 8 Russian 18 Western.

UDC 523.164

Parameters of the Temporal Harmonics of Lunar Brightness Temperature From High Resolution Observations on the RATAN-600

907Q104B Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 5, May 90 (manuscript received 12 May 1989) pp 460-467

[Article by M. N. Naugolnaya and N. S. Soboleva, Special Astrophysical Observatory of the USSR Academy of Sciences in Nizhniy Arkhyz, Leningrad Branch of the Special Astrophysical Observatory of the USSR Academy of Sciences]

[Abstract] The variable portion of the Moon's radio temperature is determined in the centimeter and decimeter range from high-resolution observations on the RATAN-600 radio telescope. By comparing the parameters of the first and second harmonics one can derive values for the variation in properties of the lunar surface with depth in a layer up to 5.5 m thick. The authors' method makes it possible to harmonically analyze the Moon more accurately at 1.35-31.3 cm. It compares radio temperatures at two points which are symmetrically positioned relative to the visual center of the Moon's disk. A system of linear equations is developed for two and three harmonics which can be solved using Gauss formulas. Drawbacks of the method are discussed. It is shown that this method has advantages over other methods when amplitudes are relatively small (long waves). Figures 2; references 10: 8 Russian, 2 Western.

UDC 520.35

Experience with the ZEBRA Echelle-Spectrometer on a 6-Meter Telescope

907Q104C Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 5, May 90 (manuscript received 28 Aug 1989) pp 473-480

[Article by E. B. Gazhur, V. G. Klochkova, and V. Ye. Panchuk, Special Astrophysical Observatory of the USSR Academy of Sciences in Nizhniy Arkhyz]

[Abstract] After modification in 1987-1988, the SP-161 Echelle spectrograph was installed at the Nasmyth-2 focus of the 6-meter telescope and became part of a three spectrograph arrangement. A light splitter was installed which allows the SP-161 to record separate wavelengths or regions of the spectrum. Parameters of Echelle spectrograms are given in the table. The ZEBRA complex optics are shown in Figure 1. The telescope complex includes a two-dimensional photon-counting system. It was found that drops in temperature at the Nasmyth-2 focus and other work modes of the telescope had a negligible effect on the quality of the spectral image and

its stability. The main source of instability is distortion of the trajectory of the light in the cathode ray tube as a result of extraneous magnetic fields. This effect is reproducible and can be corrected for. The ZEBRA complex is also to be noted for its efficient work in the ultraviolet. Figures 3; references 14: 12 Russian 2 Western.

UDC 503.12:521.95

Relativistic Frame of Reference in Near-Earth Space and Radiointerferometric Observations

907Q0105A Kiev KINEMATIKA I FIZIKA NEBESNYKH TEL in Russian Vol 6, No 2, Mar-Apr 90 pp 3-7

[Article by A. N. Aleksandrov, V. I. Zhdanov, S. L. Parnovskiy, Astronomical Observatory, Kiev University imeni T. G. Shevchenko]

[Abstract] Relativistic corrections to VLBI time delay are found through the use of a barycentric (Earth-Moon) frame of reference based on Fermi coordinates. The frame enables the determination of the homogeneous component of the Sun's gravity field and the orbital motion of the Earth-Moon barycenter. An expression is derived for the time delay in VLBI observations with an accuracy of 10^{-12} s with the antennas of the interferometer within the orbit of the moon. The expression contains a number of additional corrections which are essential when the time delays are on the order of one second. References 11: 5 Russian, 6 Western.

UDC 521.182:629.783

Integration of Equations of Motion of Low-Orbit Satellite With Taylor Method

907Q0105B Kiev KINEMATIKA I FIZIKA NEBESNYKH TEL in Russian Vol 6, No 2, Mar-Apr 90 pp 13-16

[Article by A. V. Krivov, N. A. Chernysheva]

[Abstract] In an earlier work, Babadzhanyants (PISMA V ASTRON. ZHURN., 1981, Vol 7, No 12) developed a method for numerical integration of the equations of motion in the N-body problem, based on the representation of the solution of the polynomial system of differential equations as Taylor series. This article takes the same approach in its consideration of perturbations to the orbit of a satellite that result from the nonsphericity of the earth and atmospheric drag, the main factors influencing the motion of low-orbit satellites. An optimal algorithm is developed for integration error estimation. The entire method is implemented as a FORTRAN subroutine with a total length of 2048 lines, designed to run on the YeS series of computers. The program is designed to represent the perturbing portion of the geopotential as no more than 12 point masses with a piecewise-constant density model of the atmosphere. One advantage of the method is the possibility of integration of a system with complex coefficients and initial data allowing the use of complex multiple-point models of the geopotential and analysis of motion in the complex space by methods of qualitative celestial mechanics. References 7 (Russian).

UDC 521.9-325

Influence of Moon's Shadow and Penumbra on Earth Satellite Motions

907Q0105C Kiev KINEMATIKA I FIZIKA NEBESNYKH TEL in Russian Vol 6, No 2, Mar-Apr 90 pp 17-20

[Article by Ya. E. Khelali, Yu. V. Batrakov, A. M. Fominov]

[Abstract] Equations are derived to consider the influence of the Moon's shadow and penumbra on the acceleration of an Earth-orbit satellite that is produced by solar light pressure. Estimates of the corresponding effects are produced. The equations are convenient for studying a perturbed trajectory by numerical methods. More accurate results are obtained when a conical shadow model including the penumbra is used rather than a cylindrical model. References 8: 1 Russian, 7 Western.

UDC 520.274-77

Kvazar Radiointerferometric Complex: Concepts, Tasks, Basic Parameters

907Q0113A Moscow KINEMATIKA I FIZIKA NEBESNYKH TEL in Russian Vol 6 No 3, May-Jun 90 (manuscript received 27 Nov 1989) pp 61-67

[Article by Ya. S. Yatskiv and A. M. Finkelshteyn]

[Abstract] Kvazar will be a network of six (ten are planned) fully rotating specular radio telescopes in the centimeter range (D = 32 m, F = 11.4 m) The complex will go on line in 1995. The radio telescopes are linked with a control center which collects and processes the data. Four sites have been chosen thus far for the telescopes: Priozersk, Leningrad Oblast; Zelenchukskaya, Stavropol Kray; Firyuza, Ashkhabad Oblast; and Bodary, Buryat ASSR. Moskalenki, Kiev Oblast, was initially among the sites chosen, but it was later found to be geologically unsuitable, and a new site is being sought). Consequently, two sites remain to be determined. The antennas operate in two modes: full rate, off-line; and quick look, on-line. The system will assign and construct two basic systems of coordinates—celestial and terrestrial—and will determine positions in both at each moment in time. Studies will be conducted in astrometry, geodesy, geodynamics, geophysics, radio physics, celestial mechanics, astrophysics, the general theory of relativity, and cosmology. Kvazar will operate as a very long baseline radio interferometry complex.

The maximum baseline will be about 6,000 km. The position determination error is about 0.001", angular resolution, 0.001", flux sensitivity, 0.01 Jy. Figures 3; references 3 (Russian).

UDC 521.9+520.88+550.388.8

Determination of the Spatial Characteristics of Artificial Noctilucent Formations in the Earth's Atmosphere

907Q0113B Moscow KINEMATIKA I FIZIKA NEBESNYKH TEL in Russian Vol 6 No 3, May-Jun 90 (manuscript received 11 May 89) pp 74-79

[Article by V. A. Savchenko and V. Ya. Choliy]

[Abstract] This article presents a method to analyze artificial noctilucent formations (ANF) based on equations of the geometric method of space geodesy. ANF are induced by injection of plasma into the ionosphere.

ANF are observed at two points with known coordinates and photographed against a background of stars. Calculations place these points into a geocentric system of coordinates. In the initial stages of ANF development, a resolution of several arc seconds can be obtained with an error of about 100 m. The boundaries of the ANF can be unambiguously determined only when the formation is very optically dense ($\tau > 1$), which is typical of the early stages of development of the ANF. This method enables researchers to use a computer to map the spatial evolution of the object and to determine the concentration of radiating particles in the cloud at a given moment. Further automation will provide three-dimensional representation. Figures 2; references 7: 6 Russian, 1 Western.

UDC 523.6

Use of Markov Processes Theory for Research on Spacecraft Motion in the Atmosphere

907Q0120A Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 3, May-Jun 90 (manuscript received 20 Feb 89) pp 380-390

[Article by N. L. Sokolov, T. I. Poznyak and V. B. Pinchuk]

[Abstract] Very little use has been made of the theory of continuous Markov processes for research on the flight dynamics of a spacecraft in the atmosphere. Accordingly, an attempt was made to use continuous Markov processes in obtaining the statistical characteristics of the terminal parameters of motion of a descent vehicle without carrying out massive computations of perturbed trajectories. This made possible a considerable reduction in computer time expended in obtaining quantitative estimates of the accuracy in spacecraft landing. In the first stage a solution was found for the model problem of descent of a spacecraft with a constant lift-drag ratio and angle of attack. The motion of a spacecraft is interpreted as a change in the probabilities of its presence at some fixed positions in phase space. Any final conclusion concerning the effectiveness of the method in comparison with known methods can be drawn only after its testing in solution of problems with allowance for determination of the statistical characteristics of the random process by means of the processing of real measurement data. Figures 4; references 7 (Russian).

UDC 533.6

Algorithms for Control of Vehicle Descent Range in Atmosphere With Prediction of G-Forces

907Q0120B Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 3, May-Jun 90 (manuscript received 21 Feb 89) pp 391-401

[Article by Ye. F. Kamenkov]

[Abstract] Approximate methods are described for determining the level of g-forces on all trajectory segments for direct reentry of a vehicle in the atmosphere at hyperbolic entry velocities. Algorithms are written for the control of flight range with prediction of the g-force level when there is an on-board computer in the control circuit. The proposed range algorithms are applied quite easily when using simple on-board apparatus. The concept of "region of possible descents" is introduced for linking the autonomous and nonautonomous parts of the control system. The stipulation of this region and the introduction of a nonautonomous final segment lessen the accuracy requirements on the autonomous part of the system. The results of computation of boundary descent trajectories for a vehicle in the Earth's atmosphere with control of the angle of attack and banking angle are given. Figures 5; references 6 (Russian).

UDC 535.24:523.42

Inverse Thermal Sounding Problem: Retrieval of Vertical Profile of Absorption Coefficient for Optically Active Component of Planetary Atmosphere From Observations of Outgoing Thermal Radiation

907Q0120C Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 3, May-Jun 90 (manuscript received 25 Dec 89) pp 402-412

[Article by Ye. A. Ustinov]

[Abstract] A new formulation of the inverse thermal sounding problem is proposed. A study was made of a nonlinear operator dependence relating the intensity of outgoing thermal radiation of a purely absorbing planetary atmosphere and the vertical profile of the atmospheric absorption coefficient, which in contrast to optical depth is a local spatial characteristic. It is preferable from the standpoint of clarity and comparability with physical models of the atmosphere. The variation derivative of this dependence is obtained by variation of

the expression for intensity and also on the basis of solutions of the direct and conjugate thermal radiation problems. The derived expression for the variation derivative is used in formulating the inverse problem in thermal sounding relative to the vertical profile of the absorption coefficient. In the future, plans call for use of the formulated inverse problem in interpreting data from Fourier spectrometry of the outgoing thermal radiation of planetary atmospheres in terms of the vertical profiles of atmospheric aerosol and trace gas components. References 7: 4 Russian, 3 Western.

UDC 550.388.2

Influence of Vibrational Excitation on Recombination in Ionospheric Plasma Exposed to Powerful Electromagnetic Wave

907Q0120D Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 3, May-Jun 90 (manuscript received 28 Dec 88) pp 413-417

[Article by M. N. Vlasov and T. M. Izakova]

[Abstract] When powerful electromagnetic waves penetrate the ionospheric F region, a decrease in the electron concentration is observed in the heating region. A study of this phenomenon shows that when the ionospheric plasma is subjected to the influence of such a wave, the initially heated thermal electrons may effectively transfer energy to the vibrational degrees of molecular nitrogen. The formation of vibrationally excited molecular nitrogen in the region of the main ionospheric maximum results in an increase in the recombination rate and a dropoff of the electron concentration. Theoretical computations made under conditions of heating with a powerful electromagnetic wave show that this effect considerably exceeds the influence of diffusional transport of plasma from the heated region. On the basis of these findings it also possible to explain the observed changes in emissions of unstable oxygen atoms. Figures 2: references 18: 6 Russian, 12 Western.

UDC 551.510.535

Optical Observations in Active Experiments for Research on Earth's Upper Atmosphere and Ionosphere

907Q0120E Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 3, May-Jun 90 (manuscript received 27 Jun 89) pp 418-429

[Article by G. P. Milinevskiy, Yu. A. Romanovskiy, A. M. Yevtushevskiy, V. A. Savchenko, V. V. Alpatov, A. V. Gurvich and A. I. Livshits]

[Abstract] Active experiments were carried out during 1983-1988 which resulted in development of a diagnostic instrument complex for active experiments in near-Earth space. New possibilities for research with artificial luminescent geophysical formations (ALF) are being afforded by interferometry with a high spectral resolution, such as the use of Fabry-Perot etalons in combination with highly sensitive TV apparatus. The processing of the interferograms yields data on the temperature of emitting atoms or ions and on macroscopic velocity along the line of sight using the Doppler shift. In addition to the spatial characteristics of ALF, which make it possible to investigate both the rate of diffusion and wind speed at different altitudes in the ionosphere and electrical field parameters, a factor of great importance for interpreting experimental results is determination of the photometric (brightness) characteristics of ALF. The final result of photometric processing is a determination of the concentration of the total number of emitting particles in a cloud, which makes it possible to retrieve the structure of ALF at different stages in their evolution. A package of specialized data processing programs was run on an SM 1420 computer, and it used as its initial data the results of the processing of the ALF images on the Pericolor-2000 computer. In the processing the ALF image is represented in the form of a system of isophots that make it possible to retrieve the distribution of the concentration of emitting particles with allowance for experimental parameters and observation conditions and with introduction of some model assumptions. The problem of retrieving the distribution of the concentration is solved most simply in the case of an optically thin, spherically symmetric cloud of scattering particles, but a method was also developed for determining the concentration of particles for an optically thin ellipsoidal cloud. The final result of photometric processing is the construction of isopycnic lines on the ALF image at different moments in time. The developed optical diagnostic complex makes it possible to solve most scientific and practical problems in research on the Earth's upper atmosphere and ionosphere. Figures 8; references 14: 9 Russian, 5 Western.

UDC 527.591

Analysis of Distribution of Neutral Gas in Halley's Comet Determined From Results of Local Measurements by Vega-1 Spacecraft

907Q0120F Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 3, May-Jun 90 (manuscript received 5 May 89) pp 459-473

[Article by K. I. Gringauz, A. Varga, M. I. Verigin, R. Grard, A. A. Orayevskiy, A. P. Remizov, A. K. Richter and K. Szego]

[Abstract] The Plazmag-1 instrument complex carried aboard the Vega-1 spacecraft in the vicinity of Halley's comet made it possible to plot the distribution of the concentration of neutral cometary gas n_n along the flight trajectory, estimate the acceleration of cometary gas by solar radiation pressure, and reconstruct the three-dimensional distribution of neutral particles. The concentration was estimated in a wide range of cometocentric distances 3 x 10^6-10^4 km. The principal error in estimating n_n on the basis of Plazmag data is introduced

by uncertainty in current knowledge of the values of the coefficients of secondary electron and ion emission $Y_{e,i}$ from the collectors used. The observed variations of the background current lead to uncertainty in estimating the characteristic ionization scale L μF 2 x 10^6 km. The observed difference in the n_n distribution on the approach and withdrawal segments of the Vega-1 flight trajectory is attributable to solar radiation pressure. Analysis of these and other data made it possible to construct a model of the density of neutral gas in the vicinity of Halley's comet with a characteristic form of the isolines resembling a dripstone. Figures 8; references 45: 21 Russian, 24 Western.

UDC 535.24:523.42

Global Circulation of Venusian Atmosphere

907Q0121 Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 3, May-Jun 90 (manuscript received 2 Jun 89) pp 451-458

[Article by M. N. Izakov]

[Abstract] In the Venusian lower and middle latitudes, a considerable part of the atmospheric rotation outpaces planetary rotation (superrotation phenomenon). This superrotation develops and is maintained as a result of negative viscosity, the transfer of kinetic energy from smaller to larger vortices, eventually leading to zonal flow. This phenomenon develops in a large-scale (characteristic dimensions much greater than scale height) two-dimensional turbulent flow generated when there is loss of stability of a Hadley cell forming at altitudes 55-65 km, where the absorption of solar radiation is maximal. At the same time, vorticity and temperature inhomogeneities are transferred from larger to smaller vortices, ensuring the appearance of small meridional temperature gradients. The lower-lying layers are untwisted as a result of the turbulent viscosity generated by three-dimensional turbulence. The predominantly stable stratification is a result of stronger heating of the upper layers of the atmosphere by solar radiation. It is noted that several other explanations of superrotation have been recently published. Figures 2; references 27: 12 Russian, 15 Western.

UDC 523.4

Preliminary Analysis of Venusian Tectonics and Evolution

907Q0126 Moscow GEOTEKTONIKA in Russian No 3, May-Jun 90 (manuscript received 2 Oct 89) pp 16-27

[Article by A. M. Nikishin, Geology Faculty, Moscow State University]

[Abstract] Five stages in the evolution of Venus are discussed: accretion, segregation of early crust from magma ocean; volcanic reworking of early crust, development of tectonics of soft plastic plates with formation of tesserae in compression zones and plains in dilatation zones; formation of "weakened" planetary zones of dilatation saturated by mantle hot-spot structures against a backdrop of dispersed mantle hot-spot tectonics and plateau volcanism. The following subjects are discussed: types of structures and structural regions of Venus; tectonic structure of Venus and its interpretation; thickness and composition of Venusian crust; model of geological evolution of Venus; asymmetry of tectonic structure of Venus; reasons for the great differences in the tectonics of the Earth and Venus. Figures 1, 2 and 3 show a newly compiled tectonic diagram of Venus with 16 types of zones and structures identified, the planetary system of main tectonic zones of Venus and the distribution of mantle hot-spot structures on Venus. The tectonics of Venus differ from those of the Earth because Venus was always impoverished in terms of water, a highly important agent of magmatism and the main fluid involved in the fusion of sialic rocks. Venusian volcanism was therefore less intense and a sialic crust is largely absent. The greenhouse effect on Venus, maintaining a high-temperature state at the surface, causes increased plasticity of its lithosphere, which is why the lithospheres of the Earth and Venus react differently to similar processes in the deep layers. Venus was degassed and differentiated to a lesser degree than the Earth. The Earth has a magnetic field, and Venus does not, and therefore processes in the deep layers of the two planets greatly differ. Figures 3; references 55: 35 Russian, 20 Western.

UDC 523.42-83

Homogeneous Distribution of 'Volcanic Flows' in the Northern Hemisphere of Venus

907Q0165A Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 24, No 3, Jul-Sep 90 (manuscript received 4 Jul 89, revised 19 Jan 90) pp 195-202

[Article by G. A. Leykin, V. K. Vorozdin, Ye. V. Zabaluyeva, V. I. Vernadskiy Institute of Geochemistry and Analytic Chemistry]

[Abstract] The radar of Venera 15 and Venera 16 detected a large number of small circular or irregular formations which appeared to be flowlike and of volcanic origin. This article examines the question of whether the distribution of these features is random (homogeneous) or exhibits some distribution trend.

The map of Venus displaying these features was divided into trapezoids 30 degrees of longitude and 10 degrees of latitude in size. Two methods were used to determine the distribution of the features, with subsequent statistical analysis of the numerical data. The first method compared the total area of the features to the area of the trapezoid; the second determined the number of features per trapezoid. Both methods yielded identical results, and the second was easier to implement.

It was found that the distribution of "volcanic flows" was not random in the examined region of Venus. This inhomogeneity may be due to clustering (cluster size about 1000 km). It is also possible that the "volcanic flows" are concentrated in the northern latitudes at 210-300 degrees of longitude.

However, this material is insufficient to confidently determine the distribution of these features, and studies should be done to correlate the features with morphological and geological features. Figures 4; tables 3; references 2: 1 Russian 1 Western.

UDC 523.4

Spectroscopy of Small Planets: Pyroxenes on the Surfaces of Some Bright Asteroids

907Q0165B Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 24, No 3, Jul-Sep 90 (manuscript received 16 May 89) pp 232-243

[Article by D. I. Shestopalov, L. F. Golybeva, D. G. Pogosbekov, A. A. Atai, V. Ye. Gorbanev, Shemakha Astrophysical Observatory, Azerbaijan SSR Academy of Sciences]

[Abstract] The Shemakha Astrophysical Observatory has studied ten light asteroids in the visible (400-750 nm) with high resolution spectra (about 2.5 nm). The purpose is to study the absorption bands of the crystal field of metal ions in the iron group to determine the chemical and mineral content of asteroids. These bands are weak; however, determination of the presence of these bands is needed to find achondritic material and to determine unambiguously the type of asteroid. This is difficult due to the weakness of the lines and the appearance of false features in the spectrum. Methods of verifying the presence of bands are discussed.

The presence of pyroxenes is indicated by a pair of absorption bands at 505 and 550 nm, and a band at 520-539 nm. The position of the band at 505 nm indicates that the silicate minerals of some asteroids contain ferrous and calcium clinopyroxenes. There is ambiguity in the interpretation of bands at 400, 570, and 640 nm due to questions on the reduction-oxidation potential of the mineral forming medium. These bands may be Cr^{3+} ions. A system of Fe^{3+} absoprion bands are also possible when there is a greater degree of oxidation. Figures 5; tables 3; references 21: 10 Russian 11 Western.

UDC 528.711.1(202):523.4

Selection of Surface Regions of Earth Group Planets Most Promising for Research

907Q0106 Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY RAZDEL GEODEZIYA I AEROFOTOSYEMKA in Russian No 6, Nov-Dec 89 (manuscript received 7 Apr 88) pp 100-103

[Article by A. P. Bozhok, Candidate of Technical Sciences, N. N. Rozanov, Engineer, B. V. Krasnopevtseva, Candidate of Technical Sciences, K. B. Shingareva, Docent, Candidate of Physical and Mathematical Sciences, Kiev Order of Lenin and Order of the October Revolution State University imeni T. G. Shevchenko, Moscow Order of Lenin Institute of Engineers of Geodesy, Aerial Photography, and Cartography]

[Abstract] Technological and monetary considerations limit large-scale planetary research on the Earth group planets. Determining promising surface regions for research should consist of a general strategy that has two aspects: the study of regions with distinct anomalous properties (for the planning of individual launches and small series of launches), and the search for new anomalous regions (in planning a large series of launches). In determining the scale of research, terms are defined for the areas to be studied: an "area" [Russian: *rayon*], which is investigated by a lander or by a rover, as opposed to a region [Russian: *region*], which is larger and is studied from orbit. Cartographic research has proven to be a very effective method of study, especially in inaccessible areas. The stages involved in defining a mission are discussed, from determining the objective of a mission to the selection of experiments and regions for study. Criteria are presented for ranking prospective research regions. References 2 (Russian).

UDC 521.1

Analysis of Accuracy in Determining Orbits of Phobos, Earth and Mars in Phobos Project on Basis of Solution of Model Problem

907Q0095A Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 2, Mar-Apr 90 (manuscript received 15 Dec 88) pp 212-217

[Article by S. N. Vashkovyak and N. V. Yemelyanov]

[Abstract] In the Phobos project, the Nebesnaya mekhanika [Celestial Mechanics] experiment consisted of research on the dynamics of the solar system and experimental checking of a number of physical theories. The fundamental initial data for the experiment were to be measurement data collected during the operation of a long-lived, autonomous station on the surface of Phobos. The authors study the feasibility and accuracy of the determination of the orbital parameters of Phobos, Earth, and Mars, assuming a given accuracy in the measurement of radio signals from the station. They base their study on modeling of the process of differential refining of the sought-for parameters from the measurements. The premises for the modeling of this problem are described in detail. The problem of the dependence of errors in determining the orbits of these bodies is examined in depth (the following key factors are considered: measurement interval, shift in times of measurements relative to the time of the Earth's culmination, makeup of measurements and set of determined parameters). The authors conclude that at equal measurement intervals, the best results are obtained with joint measurements of the distance between ground station and Mars-based station and radial velocity. Doppler measurements alone are ill-suited. For all types of measurements, the errors in determining orbital elements decrease with an increase in the measurement interval; but with a duration of measurements greater than 700 days, the errors cease to decrease. Shifting the times of measurement relative to the Earth's culmination improves the potential for determining the orbital parameters. References 3 (Russian).

UDC 535.24:523.42

Sulfuric Acid in Venusian Atmosphere Determined From Radio Opacity Data

907Q0095B Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 2, Mar-Apr 90 (manuscript received 27 Oct 88) pp 277-281

[Article by S. S. Matyugov, O. I. Yakovlev and V. N. Gubenko]

[Abstract] A study was made of the attenuation of centimeter ($\lambda = 5$ cm) radio waves in the polar and near-polar atmosphere of the Venusian northern hemisphere from altitudes of 47-80 km. The distribution of absorbent in the planetary middle atmosphere was also sought. The research was based on the results of measurements of the amplitude of centimeter and decimeter radio waves emitted by the Venera-15 and Venera-16 vehicles during radio opacity studies of five regions of the planetary atmosphere between latitudes of 71° and 85.5° at solar zenith angles of between 95.4° and 109° (nighttime atmosphere). The average radius of Venus was taken as $a = 6{,}051$ km. At an altitude of 61 km, the integral absorption was -2.4 dB; at 55 km, -0.6 dB; and at 47 km, -5.8 dB. Data were obtained on the absorption of radio waves at both $\lambda = 5$ cm and $\lambda = 13$ cm for altitudes 40-70 km. It was found that radio wave absorption is attributable to sulfuric acid vapor. The distribution of sulfuric acid vapor at altitudes 39-53 km was determined. At 39-44 km altitude, the content of sulfuric acid vapor is slightly dependent on altitude and is equal to 37±7 ppm. With an increase in altitude above the Venusian surface from 45 to 53 km, the content of such vapor decreases with altitude; at 47 km, it is 20±5 ppm. During the five years between the "Venera" and Pioneer Venus experiments, the sulfuric acid vapor content was found to have remained stable. Figures 3; references 12: 6 Russian, 6 Western.

UDC 535.17:523.42

Development of Model of Formation of Venusian Nighttime Ionosphere for Period of Low Solar Activity

907Q0095C Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 2, Mar-Apr 90 (manuscript received 26 Sep 88) pp 282-292

[Article by L. N. Samoznayev]

[Abstract] A two-dimensional model of the formation of the nighttime ionosphere of Venus for a period of low solar activity [T. E. Cravens, et al., JGR, Vol 88, No A7, p 5595, 1983] which takes into account the influence of two probable sources of its formation (ionization by epithermal electrons and horizontal transport of ions from the daytime side) is tested on the basis of radio occultation data from the Venera-9, -10, -15, and -16 spacecraft. A comparison of experimental and computed data supports the validity of the first of these sources; the second, together with photoionization, makes a contribution only in the region adjacent to the planetary terminator and causes a regular decrease in electron concentration at the maximum of the main layer of the ionosphere with an increase in solar zenith angle in the range of 90-110°. Although the cited data indicate a predominant influence of epithermal electrons during formation of the nighttime ionosphere, this mechanism does not explain the existence of a lower ionization maximum in the nighttime ionosphere. Since the frequency of appearance of this maximum is different in different years, it is postulated that it is formed under the influence of an unknown source whose intensity varies with the solar activity phase. Figures 4; references 36: 14 Russian, 22 Western.

UDC 625.396.94

Electron Concentration Distribution in Halley's Comet Determined by Radio Probing

907Q0095D Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 2, Mar-Apr 90 (manuscript received 24 Nov 88) pp 293-303

[Article by V. Ye. Andreyev and A. L. Gavrik]

[Abstract] The Vega-1 and Vega-2 probes carried out two-frequency radio probing of the envelope of Halley's comet during flyby of its nucleus on 6 February and 9 March 1986, during which there were considerable variations in the frequencies of radio waves in the decimeter and centimeter ranges caused by the influence of the gas-dust and plasma envelopes. The collected data were used in constructing profiles of the electron concentration in the comet as a function of cometocentric distance. In both experiments, 6 and 9 March 1986, in the segment of approach of the Vega-1 and Vega-2 to the nucleus of Halley's comet and in the segment of their withdrawal from the nucleus, there was a local electron concentration maximum at a cometocentric distance of (11.5-13.5) x 10^3 km. In both experiments the maximum electron concentration was at a distance about 11.5 x 10^3 km, where it was about 4 x 10^3 cm^{-3} on 6 March and about 2 x 10^3 cm^{-3} on 9 March. Beginning at a cometocentric distance of about 11.5 x 10^3 km there was a decrease in electron concentration to 10^3 x cm^{-3}, which may be attributable to passage of the probes through the outer boundary of the contact surface of the comet. Figures 4; references 16: 10 Russian, 6 Western.

UDC 523.42

Electric Fields, Dynamics of SO_2 Concentration, Possible Vulcanism on Venus

907Q0102 Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 24 No 1, Jan-Mar 90 (manuscript received 1 Jun 89) pp 56-71

[Article by L. V. Ksanfomaliti, Space Research Institute, USSR Academy of Sciences]

[Abstract] This is an overview of the continuing debate regarding electromagnetic pulses detected by Pioneer Venus and Venera-11 through Venera-14. The Venera pulses were presumed to be similar to terrestrial lightning. Pioneer Venus, on the night side of the planet, detected no light flashes. Vertical profiles revealed the source of the pulses to be well below the cloud layer. Furthermore, both the Venera craft and the Pioneer Venus probes encountered dense plasma at about 12 km, yet the probes were thousands of kilometers apart, indicating a global, electrically active zone. It has been conjectured that the source of the discharges is volcanic activity. A description is offered of the OEFD experiment, which detected the pulses on the Pioneer Venus, and the nature of whistlers and their propagation is explained. Its findings are interpreted to support the existence of volcanic activity. The arguments for and against vulcanism on Venus are weighed, including changes in the SO_2 content of the atmosphere, which the author believes is connected with volcanic eruption. The author presents arguments in favor of tectonic activity on Venus—for example, the need to release heat from the decay of uranium, thorium, and potassium within the planet, possible tectonic elements revealed by Venera-15 and Venera-16, and the two shield volcanoes in Beta Regio. Figures 5; References 15: 7 Russian, 8 Western

UDC 523.3

Photometry and Polarimetry of Regions of the Lunar Surface at Small Phase Angles

907Q0103A Kiev KINEMATIKA I FIZIKA NEBESNYKH TEL in Russian Vol 6 No 1, Jan-Feb 90 (manuscript received 17 Jan 89) pp 3-9

[Article by N. V. Opanasenko, Yu. G. Shkuratov, V. A. Kucherov, Astronomical Observatory of Kharkov University imeni A. M. Gorkiy, Main Astronomical Observatory of the Ukrainian SSR Academy of Sciences, Kiev]

[Abstract] The interrelations of the minimum negative polarization (P_{min}), the inversion angle (α_{inv}), albedo (A), and the opposition effect of brightness (ξ) are studied for the Moon. Error, subjective or sparse data and a lack of simultaneous polarimetric and photometric measurements had left earlier researchers with a somewhat ambiguous idea of what those relationships were. This work uses such simultaneous measurements (made in 1985-1988) of 107 regions of the Moon at small phase angles to obtain quantitative relationships for (P_{min}, A), (α_{inv}, A), and (P_{min}, ξ) and to determine the opposition peak of brightness ξ. There is a near linear dependence between P_{min} and A, with some ambiguity in areas of low albedo. As wavelength increases, α_{inv} rises, with a small increase in A. This is true of both the light and dark regions of the Moon and is distinctly manifested in the dark regions at 0.4-0.8 μm. No correlation was found between P_{min} and ξ, which was unexpected. However, as the absolute value of P_{min} A increases, ξ decreases. If this finding is confirmed, there will be some question of the generality of the opposition effect and negative polarization for the moon. The opposition peak of brightness ξ is characterized by the ratio A(12°)/A(1.2°), and was determined for two wavelengths, 0.63 and 0.42 μm. Figures 3, references 21: 18 Russian, 3 Western.

UDC 521.14/17:523.4

The Gravitational Field on the Physical Surface of Venus

907Q0103B Kiev KINEMATIKA I FIZIKA NEBESNYKH TEL in Russian Vol 6 No 1, Jan-Feb 90 (manuscript received 21 Dec 88; after revision 12 May 89) pp 19-27

[Article by T. G. Maksimova, N. A. Chuykova, State Astronomical Institute imeni P. K. Shternberg, Moscow]

[Abstract] In order to determine the distribution of gravitational potential and deflections of the vertical on a planet, one must choose a reference surface and a model of the potential of the planet, including external forces. The potentials of five forces are considered here: gravitational potential of the planet itself, gravitational potential of the atmosphere, centrifugal potential of axial rotation, centrifugal-rotational potential of orbital revolution, and tidal potential from the Sun. It is shown that the latter three potentials can be ignored in the calculation of the normal field. A dense atmosphere can have a significant effect on normal gravity gradients, and this is considered in the calculations. A potential model based on Pioneer Venus Doppler measurements is used to calculate gravitational anomalies, which are charted in Figures 1 and 2. The range of changes in gravitational variation, elevation, and deflections from the vertical are 1.7 cm/s^2, 5.7 km, and 15.6", respectively. The dense atmosphere serves to smooth gravitational anomalies caused by great changes in elevation. Conjectures are offered on the internal structure of the planet. Figures 3, references 13: 10 Russian, 3 Western.

Concise History of Expedition to Phobos

907Q0092A Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 4, Apr 90 (manuscript received 31 Jan 90) pp 293-301

[Article by R. Z. Sagdeyev and A. V. Zakharov, Space Research Institute, USSR Academy of Sciences, Moscow]

[Abstract] The loss of the Fobos-2 prevented implementation of a major part of its research program. However, during the active lifetime (almost two months) of the vehicle in a Martian satellite orbit, a large part of the scientific program for investigaing the magnetic field and the plasma environment was carried out. Television surveys of Phobos were made, photometric, spectral and radiometric investigations of Phobos and Mars were performed, as were gamma-spectrometer surveys of the

planet. Research was carried out on the chemical composition of the Martian atmosphere during entry into and emergence from the Martian shadow, and studied of the Sun and of solar activity were continued. The most interesting part of the expedition was never executed, but much information was obtained: new spectral data on the surface and mass of Phobos and updated ballistic parameters. The volume of data on Mars and their scientific quality far exceeded that of the the data obtained in all earlier expeditions of Soviet spacecraft to Mars. Table 1 lists the scientific instrumentation used in planetary research; Table 2 gives the instrumentation for plasma research; Table 3 lists the instrumentation for solar research; Table 4 gives the orbital parameters. References 23: 5 Russian, 18 Western

UDC 520.6:524.35.6

Fast Variability of Cosmic Gamma Bursts Registered in APEX Experiment of International Phobos Project

907Q0092B Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 4, Apr 90 (manuscript received 28 Dec 89) pp 302-31

[Article by I. G. Mitrofanov, J.-L. Atteia, C. Barat, G. Vedrenne, A. S. Vilchinskaya, V. Sh. Dolidze, A. V. Dyachkov, E. Jourdain, A. A. Kozlenkov, R. N. Kucherova, L. P. Moskaleva, M. Niel, A. S. Pozanenko, Yu. A. Surkov, N. G. Khavenson, V. P. Kharyukova, A. M. Chernenko and O. P. Shcheglov, Space Research Institute, USSR Academy of Sciences, Moscow; Center for Study of Space Radiations, Toulouse, France; Geochemistry and Analytical Chemistry Institute, USSR Academy of Sciences, Moscow]

[Abstract] One of the principal objectives of the Soviet-French APEX (Astrophysical-Planetological Experiment) in the Phobos project was a detailed study of the variability of transient sources of cosmic gamma radiation (cosmic gamma bursts). The experiment was based on use of a scintillation detector CsI(Tl) and an electronic module using microprocessor technology. In recording a gamma burst, the instrument recorded time profiles and spectra. The spectra were measured in 108 channels from 64 keV to 9200 keV in a "time-to-spill" mode. During the period July 1988-March 1989, about 150 events were recorded which might be identifiable with cosmic gamma bursts; about 50 of them were positively identified. Several of them are discussed in great detail: GB 880810A, GB 881024, GB 890109. Figures 9; references 22: 5 Russian, 17 Western

UDC 520.6:523.4

Initial Results of ISM Experiment

907Q0092C Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 4, Apr 90 (manuscript received 28 Aug 89) pp 318-322

[Article by J. P. Bibring, M. Combes, Y. Langevin, C. Cara, P. Drossart, Th. Encrenaz, S. Erard, O. Formi, B. Gondet, L. Ksanfomaliti, E. Lellouch, R. Masson, V. Moroz, F. Rocard, J. Rosenquist, C. Sotin and A. Soufflot, Meudon Observatory, France; Space Astrophysics Institute, France; Internal Geodynamics Laboratory, France; Space Research Institute, USSR Academy of Sciences, Moscow]

[Abstract] The ISM instrument, designed and constructed in France and used on the Phobos expedition, is an imaging spectrometer operating in the near-IR spectral region (0.76-3.14 μm). An imaging spectrometer of that range had never before been used in space. The main objective of the research was to investigate the mineralogical composition of the surfaces of Mars and Phobos, perform altimetry of the Martian surface, and collect new data on minor atmospheric components such as CO and H_2O. The procedures used in each of these types of research are briefly discussed. Some 37,000 spectra of Mars and Phobos were obtained. Over Mars, observations were made from a low elliptical orbit (altitude, approximately 2,000 km) and a circular orbit (about 6,300 km altitude). The elliptical-orbit observations consisted of two sessions in which the pixel projection size on the surface was 4 x 5 km and the imaged region was 20 x 1,600 km. The first track covered Tharsis and Pavonis Mons; the second, Biblis and Ulysses Paterae. Nine imaging sessions were performed from the circular orbit (pixel projection size, 20 x 30 km). Seven of the regions studied were in the western hemisphere below 20° latitude and between 20° and 180° longitude. Some 25 percent of the area of Tharsis and Valles Marineris was covered. A cratered region south of Arabia was also observed, as was an area that included Isidis Planitia and Syrtis Major. Observations of Phobos were made from an altitude of about 200 km (spatial resolution, 0.7 km/pixel). Among the significant findings were the following. The Martian surface exhibits great variations of albedo and color. A broad and strong absorption band in the interval 2.7-3.14 μm evidently belongs to hydrated minerals. All the Martian spectra have an absorption band at about 1 μm that apparently belongs to silicates containing the Fe^{2+} ion. Spectra of Phobos show that its albedo is approximately 4 times weaker than that of Mars in the region of Tharsis around Pavonis Mons and that the band for the hydration water

in them is far weaker, suggesting that the surface material of Phobos is closer to type C4 carbonaceous chondrites than to types C1 and C2. In the two months that Fobos-2 spent in near-Mars orbit, the ISM instrument produced not only new data concerning Mars, but also the first-ever spectra of Phobos at a resolution enabling us to determine the degree of uniformity of its surface. Figures 1; references 7: 2 Russian, 5 Western.

UDC 520.6:523.9

Solar Images Produced by TEREK X-Ray Telescope Aboard Phobos-1 Spacecraft

907Q0092D Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 4, Apr 90 (manuscript received 21 Dec 89) pp 323-329

[Article by I. I. Sobelman, I. A. Zhitnik, B. Valnicek, M. Rybansky, M. Bernas, S. V. Gaponov, R. Hudec, A. R. Ignatyev, R. V. Isajanjan, V. M. Kishchenko, M. Klima, J. Kopecky, V. V. Korneyev, O. V. Krasnopolskiy, M. N. Krmoyan, V. V. Krutov, V. M. Lomkova, A. V. Mitrofanov, S. N. Oparin, R. Peresty, A. A. Pertsov, N. N. Salashchenko, V. A. Slemzin, A. B. Telegin, V. O. Timofeyev, I. P. Tindo, A. M. Urnov, J. N. Fotin and J. M. Hodgajanz, Physics Institute, USSR Academy of Sciences, Moscow; Astronomy Institute, Czechoslovakian Academy of Sciences; Astronomy Institute, Slovak Academy of Sciences; Higher Technical School, CzSSR; Applied Physics Institute, USSR Academy of Sciences; Special Design Bureau, Byurakan Observatory, Armenian Academy of Sciences; Odessa Polytechnic Institute]

[Abstract] The first-ever long-duration observations of the Sun in which a normal-incidence multilayer mirror and CCD detectors were used to record images in the HeII resonance line (304 angstroms) and the FeIX-XI lines (170-180 angstroms) were made with the TEREK x-ray telescope aboard the Phobos-1 spacecraft. The telescope was developed by the Physics Institute, USSR Academy of Sciences, in collaboration with specialists from Czechoslovakia. An optical diagram of the instrument is given and serves as a basis for a brief description. Traditional grazing incidence optical elements were used for imaging in the range of 5-25 angstroms. About 140 X-ray images of the sun with a resolution up to 15" were produced in 14 observation sessions during spacecraft operation. The observations were made during the period 23 July-28 August 1988. A series of heliograms obtained on 26, 27, 28 August are reproduced and discussed in detail. The images reveal a variety of structures in the solar atmosphere, such as active regions, coronal holes, undisturbed coronal sectors, brightenings at the limb and formations above the limb. Figures 2; references 7: 2 Russian, 5 Western.

UDC 523.9-1/8

Results of Research on Solar Brightness Oscillations From Aboard Fobos-2 Interplanetary Station

907Q0092E Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 4, Apr 90 (manuscript received 11 Dec 89) pp 330-342

[Article by A. V. Bruns, R. Bonnet, J. P. Delaboudinier, C. Frohlich and S. M. Shumko; Crimean Astrophysical Observatory, Nauchnyy; Scientific Directorate, ESA, France; Stellar and Planetary Physics Laboratory, France; World Radiation Center, Switzerland]

[Abstract] The IFIR experiment for highly precise measurement of solar brightness in three spectral intervals was carried out from July 1988 through January 1989. The basis for the experiment was a 3-channel, highly precise photometer for measuring radiation from the entire solar disk; the instrument was equipped with a two-coordinate sun seeker in the field of vision (to compensate for the effects of changes in the spacecraft's attitude on the photometer data) and with an electronic module for data conversion, control, and interface. It was determined that changes in the power spectrum of 5-minute oscillations of solar brightness occur independently for each of the modes and have 4- to 5-hour amplitude bursts. In the overall behavior of the power spectrum lines, there are periods of quiet and active states. The quite states are characterized by an amplitude of brightness bursts 1.5×10^{-7} to 2×10^{-7} and last from 10 hours to several days. The active states consist of solitary bursts or series with an amplitude 30-50 times greater, and they last from several hours to 24 hours. The fine structure of the power spectrum lines was recorded, and the lines' contour formation was believed to be stochastic. Figures 6; references: 7: 1 Russian, 6 Western.

UDC 520.6:523.4:523.9

Ultraviolet Observations of Solar Flares From Martian Orbit

907Q0092F Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 4, Apr 90 (manuscript received 21 Sep 89) pp 343-345

[Article by T. V. Kazachevskaya, L. L. Bukusova, D. A. Gonyukh, A. I. Lomovskiy and Yu. N. Tsigelnitskiy, Applied Geophysics Institute imeni Ye. K. Fedorov, Moscow]

[Abstract] The Phobos program collected data daily on the intensity of the short-wave part of the spectrum of solar UV radiation. The measurements were made with the SUFR solar ultraviolet radiometer, which was designed to measure the flux of solar radiation in the wavelength region $\lambda < 130$ nm via thermoluminescence

The EUV measurements were made for one hour (1825-1925 UT) each day by Fobos-2 when it was orbiting Mars, approximately 239 million kilometers from the Sun. A table presents observational data for five days (in March 1989), including data for the solar flares of 8-11 March 1989. At the time, the spacecraft was moving in a circular Martian orbit approximately 9,700 km from the planet and 9,000-18,000 km from Phobos. Another table gives the dates and times of measurement of the 8-11 March solar flares, the percentage of increase in the flux of UV radiation above the undisturbed level, and the X-radiation class and optical level of flares as they were observed from the Earth. The increase in UV flux observed from Mars on 9 March at 1930 UT took place in the period between the optical flare observed from Earth (which ended at 1840 UT) and the flare (1B) that began at 1923 UT. The flare recorded from Martian orbit on 8 March at 1830 UT was not observed from Earth. The twofold increase in UV intensity in the solar flare recorded on 10 March was believed to have been linked with a powerful increase in x-radiation intensity (X4.5). The nature of the jumps in UV intensity in the solar flares generally agree with earlier measurements performed on the Solrad-11 and Prognoz-7 spacecraft. References 4: 2 Russian, 2 Western.

UDC 520.6:523.4

THERMOSCAN Experiment—Thermal Survey of Martian Surface From Fobos-2 Spacecraft

907Q0092G Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 4, Apr 90 (manuscript received 6 Dec 89) pp 346-354

[Article by A. S. Selivanov, M. K. Narayeva, A. S. Panfilov, Yu. M. Gektin, V. D. Kharlamov, A. V. Romanov, D. A. Fomin and Ya. Ya. Miroshnichenko, Scientific Research Institute of Instrument Making, Moscow]

[Abstract] A brief description is given of the TERMOSKAN experiment for investigating the thermophysical properties of the Martian surface with the Termoskan scanning radiometer carried aboard the Fobos-2 spacecraft. The instrument recorded images of the Martian surface in the thermal (8.5-12 μm) and visible and near-IR (0.6-0.95 μm) spectral ranges with a spatial resolution severalfold better than any earlier obtained resolution. The preliminary results of an 11 February 1989 survey of the Martian surface from an intermediate elliptical orbit (at altitudes of 1150-5200 km) and a survey performed from a circular orbit (altitude, 6300-6400 km) on 1 March 1989 and 26 March 1989 are given. The best resolution at the Martian surface was about 300 m in the first survey and 1.8 km in the later surveys. Images in the thermal and visible parts of the spectrum of the equatorial sectors of the Martian surface are given and discussed. The 26 March survey produced images for the first time ever of the shadow of Phobos on the Martian surface in the thermal spectral range. During all the surveys, the radiation temperatures of the surface were in the range 180-280 K; temperature contrasts were up to 20-30 K. The principal tasks accomplished by the surveys consisted of the following: thermal images were obtained for a considerable part of the Martian equatorial zone with a resolution 0.3-2 km; diurnal variation of radiation temperature was measured; data were obtained on temperature gradients of closely situated relief features; data were obtained on surface temperature gradients in zones where the shadow of Phobos passed; data were collected for estimating the thermal inertia of the soil. Figures 4, references 10: 4 Russian, 6 Western.

UDC 520.6:523.4

Determination of Elemental Composition of Martian Rocks From Fobos-2 Spacecraft

907Q0092H Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 4, Apr 90 (manuscript received 13 Dec 89) pp 355-362

[Article by Yu. A. Surkov, L. P. Moskaleva, V. P. Kharyukova, S. Ye. Zaytseva, G. G. Smirnov and O. S. Manvelyan, Geochemistry and Analytical Chemistry Institute, USSR Academy of Sciences, Moscow]

[Abstract] A multichannel scintillation γ-spectrometer was carried aboard the Fobos-2 spacecraft for investigating the composition of Martian rocks. The instrument used a 100 x 100 mm CsI(Tl) detector and operated in the range of 0.3-10.0 MeV. After reaching Mars in January 1989, the spacecraft spent three weeks in a three-day-long elliptical orbit that brought the vehicle as close as 870 km from the surface and took it as far away as 80,000 km. The plane of the orbit was inclined 1° from the equatorial plane. Gamma emissions were measured in perigee, background emissions at apogee. Measurement of the gamma emissions began when the spacecraft was 5,000-10,000 km from the surface, and each gamma spectrum was observed for 10 minutes. This paper reports the results of the analysis of gamma spectra measured at the lowest points in the orbit (in particular, a point designated RS-3). The composition determined by the Fobos craft appears to reflect a mixture of surface material and bedrock. The subalkaline basalt found on islands in the Earth's oceans appears to be the closest analog to the Martian rock analyzed. Figures 4; references 6: 3 Russian, 3 Western.

UDC 520.6:523.4

Observations of Electron and Ion Fluxes Near Mars With KhARP Spectrometer on Fobos-2 Spacecraft

907Q0092I Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 4, Apr 90 (manuscript received 7 Sep 89) pp 363-367

[Article by N. Shutte, P. Kiraly, T. Cravens, A. Dyachkov, T. Gomboshi, K. Gringauz, A. Nagy, W.

Sharp, S. Sheronova, K. Szego, T. Szemerey, I. Szucs, M. Tatrallyay, A. Todt (deceased) and M. Verigin, Space Research Institute, USSR Academy of Sciences, Moscow; University of Michigan; Central Institute for Physical Research, Hungary]

[Abstract] The preliminary results of electron- and ion-flux measurements made in the vicinity of Mars on 1 February and 5 February 1989 with the KhARP energy spectrometer on the Fobos-2 vehicle in its first and second elliptical orbits are given. The KhARP differential hyperbolic analyzer made it possible to measure charged particles with *E/q* of 0.2-800 eV in antisolar half-space. The energy and anglular distributions of electrons were measured within a solid angle of 160° x 20° x 10° in eight fixed directions. The results reported here pertain mainly to electrons. It was found that in the transitional layer of the magnetosphere the energy distributions have two distinct maxima. Similar spectra were also observed in the plasma sheet in the areomagnetic tail. Measurements of the electron energy spectra along the orbit show that sharp variations in type of distribution are found at the intersections of shock wave, magnetopause, and plasma sheet, the boundaries of which coincide with measurement data published by Rosenbauer *et al.* (PISMA V ASTRON. ZHURN., 1990, Vol 16, No 4, p 368). The physical mechanisms responsible for the acceleration of electrons behind the shock wave front and for the appearance of energy distributions with two maxima are still unknown, but it is expected that the problem will be solved by comparison with data from other Fobos plasma and magnetic observations and other data. Figures 3; references 5: 2 Russian, 3 Western.

UDC 520.6:523.4

Initial Results of Measurements of Ions of Martian Origin and Detection of Plasma Sheet in Martian Magnetosphere From Data of TAUS Experiment Aboard Fobos-2 Spacecraft

907Q0092J Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 4, Apr 90 (manuscript received 7 Sep 89) pp 368-377

[Article by H. Rosenbauer, N. Shutte, I. Apathy, M. Verigin, M. Witte, A. Galeyev, K. Gringauz, H. Grunwaldt, K. Jockers, R. Kiraly, G. Kotova, S. Livi, E. Marsch, A. Remizov, A. Richter, W. Riedler, K. Szego, P. Hemmerich, R. Schwenn, K. Schwingenschuh and M. Steller]

[Abstract] The TAUS instrument aboard the Fobos-2 was used to make detailed measurements of energy and angular spectra of ions arriving from the Sun while the spacecraft was in its Martian satellite orbit; the measurements were made within a solid angle 40° x 40° toward the Sun. The measurements confirmed results obtained earlier by the Mars 2, -3, and -5 spacecraft, and they were the first plasma measurements made deep in the optical shadow of the planet (there had been never been any mass-spectrometry of ions in near-Mars space). The the Martian magnetosphere was found to be filled, to a large extent, with fluxes of heavy ions emanating from the planetary atmosphere; a plasma layer that also, for the most part, consists of heavy ions was discovered in the areomagnetic tail. The flux of planetary ions escaping from Mars through the areomagnetic tail is, according the preliminary estimates, 0.5×10^{25} s^{-1} to 2×10^{25} s^{-1}. Figures 4; references 12: 3 Russian, 9 Western.

UDC 520.6:523.4

Initial Results of Television Surveys of Phobos

907Q0092K Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 4, Apr 90 (manuscript received 4 Sep 89) pp 378-388

[Article by G. A. Avanesov, B. I. Bonev, F. Kempe, A. T. Bazilevskiy, V. Boycheva, G. G. Wiede, P. Gromatikov, T. Duxbury, M. Danz, D. Dimitrov, B. S. Zhukov, Ya. L. Ziman, V. Kolev, V. I. Kostenko, V. A. Kottsov, V. M. Krasavtsev, V. A. Krasikov, A. Krumov, A. A. Kuzmin, K. D. Losev, K. Lumme, D. Mohlmann, S. Murchie, D. N. Mishev, K. Muinonen, V. M. Muravyev, B. Murray, W. Neumann, L. Paul, W. Possel, D. Petkov, P. Petuchova, B. Rebel, S. Simeonov, B. Smith, A. Totev, Yu. Uzunov, V. P. Fedotov, D. Halmann, J. Head, V. N. Heifets, H. Zapfe, K. N. Chikov and Yu. G. Shkuratov, Space Research Institute, USSR Academy of Sciences, Moscow; Precise Mechanics and Optics Institute, Leningrad; Space Research Institute, Bulgarian Academy of Sciences, Sofia; Cybernetics and Information Processes Institute, GDR Academy of Sciences, Berlin; Space Research Institute, GDR Academy of Sciences, Berlin; Geochemistry and Analytical Chemistry Institute, USSR Academy of Sciences, Moscow; Kharkov University, Brown University, Providence; Jet Propulsion Laboratory, Pasadena; Helsinki University, Finland; California Institute of Technology, Pasadena; University of Arizona, Tucson]

[Abstract] The objectives of the Phobos TV experiment were (1) to survey Phobos from circular and quasisynchronous orbits for a global view of the surface of Phobos and for more precise determination of its orbital motion for routine solution of navigational problems and (2) to survey Phobos with a centimeter resolution while the spacecraft was in a gliding drift 50 m above its surface. The Fregat videospectrometer complex was developed for this purpose by Soviet, Bulgarian and East German specialists. The unit included a three-channel TV camera, a spectrometer, and 1.5 Gbit video memory (a limited amount of video data could also be stored in the Morion memory). The TV camera had two short-focus channels and one long-focus channel, with angular resolutions of 3.3 x 4.5 and 0.62 x 0.83 minutes of arc, respectively. CCD matrices with two sections, for storage and memory, with working dimensions of 288 x 505 pixels were used as the radiation detectors in the TV camera and the spectrometer. Because of the early demise of the Fobos spacecraft, however, TV images of

Phobos were obtained from distances of 200-1100 km only, a total of 37 images of Phobos (some with Mars in the background) were obtained, with a time interval of 1 minute 20 seconds between images and 15-30 minutes between series. These images supplement TV information from the Mariner 9 and Viking spacecraft with respect to coverage of the surface of Phobos and resolution in some regions, as well as spectral range and phase angle interval. The images will make it possible to define more precisely the shape of Phobos, to refine the topographic and geological maps of the surface of Phobos, and to determine in greater detail its spectral and angular reflective characteristics, surface composition and texture, librational motions, and center of mass. Figures 4; references 19: 3 Russian, 16 Western.

UDC 520.6:523.4

Inhomogeneities of Thermal and Reflective Properties of Phobos Surface

907Q0092L Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 4, Apr 90 (manuscript received 6 July 89) pp 389-395

[Article by L. V. Ksanfomaliti, V. I. Moroz, J.-P. Bibring, M. Combes, A. Soufflot, O. F. Ganpantserova, N. V. Goroshkova, A. V. Zharkov, G. Ye. Nikitin and Ye. V. Petrova, Space Research Institute, USSR Academy of Sciences, Moscow; Space Astrophysics Institute, Orsay, France; Meudon University, France]

[Abstract] The Fobos-2 carried the combined multichannel KRFM instrument, consisting of a radiometer with a resolution of 30 minutes of arc for measuring thermal radiation in the range 6-50 μm and a photometer with an angular resolution of 15 minutes of arc; the photometer had nine subranges in the spectral interval of 0.32-0.6 μm. For two months, this instrument was used for investigation of Mars from orbit. During the last days of its lifetime, observations were made of Phobos from a distance of 190 km. The velocity of the vehicle relative to Phobos was 43 m/s, and for approximately 420 seconds, a path was investigated at approximately -4°.5 latitude from 140 to 260° W long. A second pass was made along 2°.5 latitude from 197 to 229° W long. Preliminary data are given on the profiles of brightness temperature along both paths. Estimates of the reflective properties are given. These data show that the surface is not uniform in its thermal and spectral reflective characteristics. This is the first direct evidence of nonuniformities in the structure and composition of primary celestial bodies in the solar system. Figures 4; references: 7 Western.

UDC 520.6:523.4

Refinement of Gravitational Constant of Phobos on Basis of Fobos-2 Trajectory Tracking Data

907Q0092M Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 16 No 4, Apr 90 (manuscript received 12 Jun 89) pp 396-400

[Article by Yu. F. Kolyuka, A. Ye. Yefimov, S. M. Kudryavtsev, O. K. Margorin, V. P. Tarasov and V. F. Tikhonov]

[Abstract] Until recently, the value of the gravitational constant of Phobos was determined by various authors on the basis of Viking data. Their estimates, however, varied widely. A new, more precise value of this parameter has now been found on the basis of trajectory tracking of Fobos-2 during its prolonged presence close to Phobos. The sources of possible errors are analyzed. The new value of the gravitational constant is (7.22+/-0.05) x 10^{-4} km^3/s^2, which corresponds to a mass of (1.08+/-0.01) x 10^{19} g for the moon. The initial data used and the assumptions made in the pertinent calculations for arriving at these values are given. Figures 2; references 3: 1 Russian, 2 Western.

Cosmonaut Arzamazov Interviewed on Role of Physician-Biochemist in Spaceflight

907Q0093 Moscow RABOCHAYA TRIBUNA in Russian 12 Apr 90 p 2

[Interview with Doctor German Semenovich Arzamazov by RABOCHAYA TRIBUNA correspondent A. Fedorov, under the rubric "Today Is Space Program Day": "One Who Has Not Yet Gone Up...: Doctor German Arzamazov Responds to RABOCHAYA TRIBUNA's Questions"; first four paragraphs are source introduction]

[Text] **The automatic landing system failed during the reentry. "We're going to land manually," the commander's transmission to the ground said, but the Flight Control Center did not answer—the spacecraft had already entered the atmosphere's dense layers.**

The capsule fell on the cold sand of the desert in the night. But during the daytime, the heat here will be in the neighborhood of about 50°, thought the flight engineer as he looked doubtfully at several canisters of stored water from the emergency rescue kit. The navigation lights of a TU-154 passed overhead, high in the sky. Was it on the way to Ashkhabad? To Mary? To Kabul?

They set to work: they unpacked the radio set and pressed the transmit button. Not a sound. From the radio beacon, silence. The set was dead. They recalled what they had been taught during their years of training. They took off their space suits until they were in just their underwear—it would be easier to tolerate the heat that way. Then they adjusted the parachute canopy—the lightweight fabric protected them from the scorching rays. There was only one thing left for them to do—wait for help and try to survive.

I won't toy with the curiosity of the readers any further. The ending of this story, which really took place, is a happy one: the cosmonauts were "found" after three days, and they were alive and healthy, although it is true that by then they had each lost 5 kilograms of weight. It was no accident that I put the word *found* in quotation marks—the situation was simulated from beginning to end by the specialists from the Biomedical Problems Institute, and the three days of total isolation in the desert is a form of unique survival training for spaceflight candidates. And one of those "Robinson Crusoes" was the space doctor, German Arzamazov, whom I'm interviewing today.

[Fedorov] German Semenovich, it is likely that, if one collected all the publications on space which have come out over the last 30 plus years, all the books and magazines—the result would be an impressive library. But, it seems to me that one shelf would still be empty there— the story about the backup crews who didn't go aloft and the individuals who didn't become cosmonauts. For a long time, new space launches were reported "after the fact," and the research programs were reported only if their were successful. Now, it seems, those times have passed, but, as before, we know very little about those who are being trained to take a place in a spacecraft. All the same, I would like to hear answers to questions about who they are and what they are doing, why they want to go up into space and how they view the prospects for its development. That is precisely why I invited you to talk with me—since you are a cosmonaut who hasn't been aloft yet. My first question is the traditional one: who are you?

[Arzamazov] To be brief, like a newspaper report, this is it: I am 44 years old and was born into a teacher's family in Gorky Oblast. My parents died early, and my grandmother raised me. I completed medical school, served in the army and then entered the First Moscow Medical Institute. After finishing there, I studied in the graduate program of the USSR Ministry of Health's Biomedical Problems Institute, to which I was then assigned. I work there to this day, and I am a physician-biochemist by profession. I have been in the cosmonaut corps since 1976, and I was the backup crewmember for Doctor V. Polyakov. I'm married and have two children.

[Fedorov] A physician-cosmonaut—that sounds quite unusual.

[Arzamazov] Yes, it is, when you consider the fact that over three decades, only three doctors in all have gone into space aboard Soviet spacecraft—B. Yegorov, O. Atkov and V. Polyakov. At the dawn of space research, medicine was faced with the question: can a person live at all under the conditions of weightlessness—can he breathe, take food and maintain his coordination and efficiency? Then, when it was established that long-duration flights were possible, different questions began to be asked: but how is he to live there, what is best to eat, and what should be done in order to reduce to a minimum the undesirable impact of outer space? We are used to the idea that a healthy individual doesn't need a doctor. I would venture to assert that, in space, everyone needs a doctor.

[Fedorov] Previously, a favorite phrase in official reports about missions was "Everything is proceeding normally and the cosmonauts feel fine." Today, we state: two "were brought down" from orbit ahead of schedule because of illness, two died on the ground and four died during the landing. Which means, space is not such a harmless thing?

[Arzamazov] We can accurately calculate the parameters of any kind of piece of iron, we can compute its volume, weight and material composition. But a person? No doctor in the world has yet been able to get to know a person completely. It is true that space does not like jokes. Indeed, even medicines and the ordinary tablets made on the ground, have a much stronger effect on many cosmonauts when they come out of the onboard medicine cabinet.

[Fedorov] It is likely that each candidate has an individual program—what he would most like to do there on the station. Could you tell me something about your own program?

[Arzamazov] First of all, care for the crew's health. After all, problems from time to time come up even during takeoff: some individuals begin to feel apathy, while others have vestibular system disorders. In space, everything is not as simple as it seems at first glance. That is precisely why I constantly work to improve my skills as a practitioner: I work in clinics, I perform operations. A doctor is also obligated to create a psychologically comfortable atmosphere for his crew, and he must be able to cheer them up and maintain morale—after all, that's also very important. And, in general, I see a lot of interesting work still to be done there. I will begin with my own field—biochemistry. We don't have that much information at present about the changes which occur in the body—for example, details about the water-salt metabolism, the functioning of the kidneys, and the potassium metabolism in cells.

[Fedorov] These days, when we talk about space, we allude to such concepts as cost accounting, profit, the cost recovery of missions, and the practical benefit of those missions...

[Arzamazov] All that is correct, but there is also still basic research, from which it is difficult to expect an instantaneous return expressed in rubles and in hard currency. We are acquiring knowledge and, in return, we are making the most of the experience. For example, space medicine has given serious impetus to the development of physiology. I would even call it a revival. We have again begun to study the normal healthy person. Isn't that a plus? And there's more. The time is just over the horizon when people will fly to the Moon and to Mars and will build factories in orbit. Indeed, we doctors need to learn how to practice medicine in space. It will also likely be necessary to perform operations and treat people and, perhaps, even deliver babies. We need to start with little things, but we need to start now. And, finally, one last thing: it seems to me that one of the American astronaut-doctors said that a week on the Shuttle gave him more knowledge about space medicine than years of studies on the ground. Certainly, most specialists can only dream about such an assignment.

[Fedorov] I understand you quite well. I'm also trying for that, and I took part in the jounralists' space competition. I hope this dream of mine comes true. But let me knock on wood three times and ask the following question: what will happen if you never get to go up into into space?

[Arzamazov] Someone else no less worthy, no less competent, will go up. Maybe it will be one of my comrades—doctors Lena Dobrokvashina, Aleksandr Borodin, or Boris Morukov. It wouldn't be a tragedy for me, because I have interesting work on the ground, too, and because the corps and the training in it have given me an awful lot already. I feel truly sorry for those who bet everything on one card—their desire to go up into space—and lose. Just what does a flight represent in the big picture? A bright episode in life, a stroke of luck. As long as the space program places such high requirements on the training of candidates and their health, a flights into space will be a rarity. And that is why I will calmly thank my instructors, the doctors, the experts and my fellow cosmonauts. But I'd still like to go up, of course.

[Fedorov] Well, I wish you luck from the bottom of my heart and congratulate you on the holiday.

[Arzamazov] Thanks, and the same to you.

Soviet-Canadian Meeting on Space Biology

LD0511064790 Moscow TASS in English 0629 GMT 5 Nov 90

[By TASS correspondent Valentin Vasilets]

[Text] Ottawa November 5 TASS—Mutual benefits of cooperation and good prospects for its development were pointed out by participants in the first meeting of the Soviet-Canadian working group on space biology and medicine.

The results of two joint experiments on the Soviet biology satellite Cosmos-2044 last year were summed up for the session which was held in Ottawa and Montreal from October 30 to November 5.

The Soviet delegation acquainted the Canadians with a program for research by means of yet another biosatellite which is to be launched next year and invited the Canadians to participate in the program.

The two countries' scientists decided to concentrate their joint efforts on four areas of space biology and medicine: neurovestibular physiology, metabolism, radiation dosimetry, and gravitational biology.

The working group's two co-chairmen—Cosmonaut Valeriy Polyakov, deputy director of the Institute of Medico-Biological Problems, and Allan Mortimer, head of the Biology and Medicine Department of the Canadian Space agency—regard the research in these problem areas as extremely important for preparing space flights that would last for years

'Zenit' Booster Launch Failure 4 Oct

*907Q0003a Moscow IZVESTIYA in Russian
11 Oct 90 p 3*

[TASS Report: "At the Baykonur Cosmodrome"]

[Text] Flight Control Center, 11 Oct (TASS). On 4 October 1990, a "Zenit" booster rocket, used to orbit artificial earth satellites, was being launched at the Baykonur cosmodrome. The rocket was destroyed during the initial seconds of its flight. There was damage to one of the two launch pads of the launch complex. No personnel were injured. A commission of specialists is investigating the causes of the accident.

UDC 629.7

Optimal Reorientation of Spacecraft in 'Rocking' Mode With Engines With Unequal Moment Arms

907Q0096B Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 2, Mar-Apr 90 (manuscript received 10 Oct 88) pp 198-202

[Article by I. V. Ioslovich]

[Abstract] The problem of optimal reorientation of a spacecraft with the "rocking" mode was defined and solved by the author in an earlier study (KOSMICH. ISSLED., Vol 24, No 3, p 376, 1986). In that problem. the spacecraft was regarded as a solid body having an initial rotation about a main central axis of inertia. The attitude control system includes pairs of jet engines generating controlling moments in both directions about the main axes. The rocking, which is a version of zero-overshoot response, is effected by alternately actuating controlling moments perpendicular to the initial stationary rotation at moments of half turns of precessional rotation. The problem has now been solved with the most general assumptions concerning the range of input constants and initial conditions. The so-called passive integrals method (K. G. Grigoryev, et al., "Problems in Optimal Control of Cyclic Processes," IZV. AN SSSR: TEKHN. KIBERNETIKA, No 4, p 38, 1984) is used to generalize the solution for engines with unequal moment arms. The author points out that the pair of engines used for boost does not necessarily expend the same quantity of mass per increment of unit angular velocity as does the pair of engines used for braking. That situation comes about when, for technical reasons, those pairs of engines have moment arms of differing magnitude. The author constructs an optimal synthesis procedure that is converted into the solution he produced in his earlier work. Figures 2; references: 10 Russian.

UDC 629.191

Stability of Motion of Maneuvering Elastic Spacecraft

907Q0096C Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 2, Mar-Apr 90 (manuscript received 10 May 88) pp 203-211

[Article by Ye. M. Potapenko]

[Abstract] Simple methods were developed for analysis of stability of motion of an elastic spacecraft executing major spatial maneuvers without restriction on the number of tones of elastic oscillations taken into account. The formulation and proof of the theorems employed in this study do not change if the operation of the spacecraft sensors and regulators is described by equations differing from those used in this article; nor do they depend on whether controllable or uncontrollable rotors and gyroscopes are installed in the spacecraft body. The stability criteria formulated in the article do not require a knowledge of the dynamic characteristics of a spacecraft that allow for its elasticity, or they require a minimal knowledge only. The demonstrated theorems reduce the problem of investigating the stability of a distributed system to a problem that does not require allowance for elasticity, which substantially simplifies the problem. Any system synthesized on the basis of the presented theorems will be stable relative to the spacecraft parameters characterizing its elasticity. References 9: 7 Russian, 2 Western.

UDC 531.381

System for Controlling the Attitude of Deformable Spacecraft With Dynamic Filter

907Q0123A Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 3, May-Jun 90 (manuscript received 9 Jun 88) pp 329-335

[Article by G. Ya. Ledenev]

[Abstract] Increasing the dimensions of a spacecraft while simultaneously decreasing the weight of its structural elements and the inflight creation of complexes that are more or less docked with the spacecraft leads to diminution of structural rigidity. Attitude control for such facilities is complex. Since the attitude-control sensors are located on the spacecraft itself and, under certain conditions, the amplitude of the angular velocity and angular deviation of the spacecraft as a deformable body can grow in an unlimited fashion, sometimes control switching is determined exclusively by the coordinates of elastic oscillations, which leads to loss of stability. The inadequacy of the known methods for attenuating the influence of elastic oscillations led the researcher to seek out adequate conditions for stable control when a deformable spacecraft with a dynamic filter is exposed to the influence of slowly changing perturbations. With virtually no distortion, the dynamic filter examined transmits a useful signal, considerably

attenuates the signal of elastic oscillations and excludes the influence of a slowly changing perturbation on attitude-control precision. Expressions are derived which make it possible to select the parameters of a dynamic filter that provides stability to the attitude-control system of the spacecraft. The satisfaction of stability conditions at the minimal possible frequency of elastic oscillations ensures their satisfaction at all other frequencies as a result of a sharp suppression of the signal of elastic oscillations at higher frequencies. Attainment of stable control does not require complete a priori information on the external perturbations of a spacecraft and the frequency spectrum of elastic oscillations. Figures 3; references 7 (Russian).

UDC 629

Optimal Algorithms for Limitations on State of Space Vehicle With Relay End Effectors

907Q0123B Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 3, May-Jun 90 (manuscript received 15 Feb 89) pp 336-345

[Article by N. Ye. Zubov]

[Abstract] Optimal and quasioptimal algorithms for multiparameter limitations on the state of a spacecraft with relay end effectors are written on the basis of a predictive model. The groundwork for this work was a study by V. N. Bukov and N. Ye. Zubov ("Relay Control on Basis of Algorithm With Predictive Model" in AVTOMATIKA I TELEMEKHANIKA, No 6, pp 36-42, 1986). Application of the algorithms is illustrated in several examples. The algorithms make it possible to reduce the number of computation operations by decreasing the dimensionality of the control vector used in the computations and by simplifying the control computation procedure by means of integration of the equations which are provided in this article. In the first example, the volume of computation work was reduced by a factor of 8.2 as a result of the decreased dimensionality of the control vector and the simplification of the computation procedure, whereas in the second example, computation expenditures were reduced by only a factor of 1.3, exclusively the result of a simplification of the computation procedure. Figures 4; references 5 (Russian).

UDC 629.78

Hydraulic Channel Dampers of Nutational Oscillations

907Q0123C Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 3, May-Jun 90 (manuscript received 23 Feb 89) pp 346-351

[Article by A. Yu. Kogan]

[Abstract] Dampers of mechanical oscillations are usually incorporated in passive spacecraft attitude-control systems. Most proposed designs have two properties that make them unsuitable for precision attitude-control systems: a zone of insensitivity and variability of spacecraft centering and in its inertia tensor as a result of the displacement of damper mass. A hydraulic channel damper (a closed tube filled with a viscous fluid) is free of these shortcomings, and there is free choice in selecting its geometry. Numerical simulation of the motion of a spacecraft with such a damper involves integration of a system of ordinary differential equations of spacecraft rotation and equations in partial derivatives describing fluid motion. Solution of this problem involves considerable difficulties. However, if the fluid mass is small, the dynamic equations can be solved by the successive approximations method. This problem is solved with solutions correct for any Reynolds number. Formulas are given for the parameters of a flywheel damper equivalent to it. Figure 1; references: 4 Western.

UDC 531.28

Field of Applicability of Gyroscope-Powered Systems

907Q0123D Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 3, May-Jun 90 (manuscript received 30 Jan 89) pp 352-359

[Article by V. P. Legostayev and Ye. N. Tokar]

[Abstract] The range of applicability of spatial gyrodyne systems is examined for gyroscope-powered stabilizers with constant-velocity rotors. The article constitutes a continuation of primarily the extensive previous work of the Ye. N Tokar along these lines (KOSMICH. ISSLED., Vol 16, No 1, pp 22-30, No 2, pp 179-187, No 4, pp 505-513, No 5, pp 675-685, 1978; Vol 18, No 2, pp 147-156, No 3, pp 307-315, 1980; Vol 19, No 3, pp 346-358, No 6, pp 813-822, 1981; Vol 27, No 3, p 368, No 6, 1989). The dependence of the principal parameters of gyrodyne attitude-control systems on the mass of orbital stations and the form of their central ellipsoids of inertia is analyzed. The problem of matching of the parameters of the stations and the gyrodyne systems controlling them is discussed. The parameters of spatial gyrodyne systems necessary for control of orbital stations with different characteristic dimensions and masses ensuring these stations identical maneuverability are considered. On the basis of these results the limits of applicability of such systems are given for large orbital structures. Figures 2; references 12 (Russian).

UDC 531.36

Precision of Stabilization of Orbital Station by Gyrodyne System

907Q0123E Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 28 No 3, May-Jun 90 (manuscript received 29 Jun 89) pp 360-365

[Article by N. N. Sheremetyevskiy, D. M. Veynberg and V. P. Vereshchagin]

[Abstract] In the control of the angular position of a spacecraft, extensive use is made of electromechanical systems which ensure highly accurate pointing, with virtually no fuel expenditure. The construction of mathematical models of these systems is highly important in solving the pointing accuracy problem. The mathematical model of a powerful gyroscope-gyrodyne examined in this study is used in both the ground-based preflight development of the system and in inflight analysis of different pointing modes of the Mir orbital complex. The model is made more precise and is represented in the form of a system of simple differential and algebraic equations correctly reflecting the dynamics of the gyrodynes. On the basis of variation of some parameters of the model, ways to improve gyrodynes are considered which make it possible to increase system accuracy as a whole. Using the presented digital model and appropriate correction of the parameters of the main gyrodyne components, the pointing accuracy can be increased from 1 minute of arc to several seconds of arc. Figures 4; references 4: 2 Russian, 2 Western.

Satellite Geodesy and Earthquake Prediction

907Q0115 Moscow ZEMLYA I VSELENNAYA in Russian No 3, May-Jun 90 pp 13-19

[Article by Doctor of Technical Sciences M. T. Prilepin, Earth Physics Institute imeni O. Yu. Shmidt, USSR Academy of Sciences; first paragraph is source introduction]

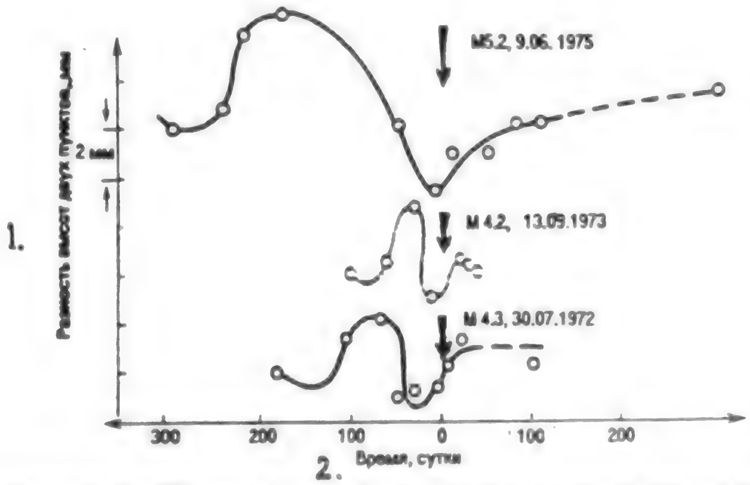
[Text] *Motions and deformations of the earth's crust that may provide warning of impending seismic events have been studied for many years in geodynamic test areas by geodesists of a number of countries. However, the methods of ground-based geodesy are often extremely limited, and they do not yield enough observational material for earthquake prediction. Scientists are now laying high hopes on satellite geodesy. Satellite measurements make it possible to obtain information on deformation of the earth's crust over enormous territories within relatively short periods of time, with much greater accuracy than is achieved with ground-based methods.*

The Role of Geodesy in the Forecast Problem

In the current views of geologists and geophysicists, the earth's lithosphere consists of **tectonic plates** of various classes—from plates as large as continents to blocks as small as dozens of kilometers across. Thermal anomalies and density inhomogeneities in the Earth's interior serve as the primary "action centers" that cause the movement of the plates. They can occur only in relatively narrow, weakened zones—faults. As they move, plates may "catch" on each other, as a result of which **deformations** occur in the upper, rigid parts of the plates, and internal **stresses** begin to build up. When the stresses exceed the ultimate strength of the rock, the edges of the faults suddenly slip against each other. As a result, seismic energy is released—it is what is perceived as an earthquake (the critical stresses at which earthquakes occur in the earth's crust correspond to relative deformations of $(1\text{-}5) \times 10^{-4}$). The relative displacement of the sides of faults are quite substantial in destructive earthquakes. For example, in the Spitak earthquake, vertical displacement of the sides of the fault reached 2 m, while horizontal displacements reached 1.5 m.

Many geologists and geophysicists feel that the overall tectonic situation in the earthquake regions of Central Asia is associated with collisions of two lithospheric plates—the Indo-Australian and the Euro-Asian. We should note that the Spitak earthquake zone is also a region of interaction between the Arabian and Euro-Asian plates. Clearly, we must be able to directly measure the movements of tectonic plates and blocks of all classes in relation to one another. Such measurements are made by **geodetic methods** because those very methods possess the needed precision to record small displacements of the earth's surface.

In our country, the first geodetic studies having the purpose of earthquake prediction began back in 1946. At that time, in the vicinity of Garm, in Tajikistan, the first geodetic network was developed (for triangulation and leveling), tying-in the Pamir and Tien Shan systems. Such work is also being done today in many of the USSR's geodynamic test areas (there are more than 50 of them). The principal method of studying horizontal displacements is **trilateration.** Unlike triangulation, trilateration determines terrain coordinates by using ground-based laser rangefinders to measure the length of the sides of triangles (ZEMLYA I VSELENNAYA, No 5, 1979, p 70.—*Ed.*), rather than their angles. Vertical displacements are measured by **geometric leveling.**



Curves showing change in the difference between the heights of two points before and after an earthquake, determined by means of geometric leveling (Garm test area, Tajik SSR). The moments at which the earthquakes hit are indicated by arrows; the magnitudes of the earthquakes and their dates are indicated as well. The nature of changes in the height difference in these three cases may be viewed as a predictive sign of a seismic event

Key: 1. Height difference between two points, in mm—2. Time, in days

Geodetic methods of studying movements of the Earth's crust to assess seimic hazard are being used in Japan (essentially all of this country's territory is a single geodynamic test area, with a dense network of triangulation, trilateration and leveling points), in the United States along the San Andreas Fault and in Alaska, and in China.

What Do Space Methods Provide?

Of course, the methods of classical geodesy are suitable only for small test areas, and observations must be repeated very frequently. Moreover, this work is extremely expensive, it cannot be done in many places, and it depends heavily on meteorological conditions. And most important, it is often unsatisfactory in terms of accuracy. Specialists, naturally, have turned their eyes to **space methods,** which can be used to study the movements and deformations of the Earth's crust over enormous areas—over tectonic plates and blocks of the largest classes.

It must be said that American specialists are ahead in this research—they have been conducting specific precision measurements of displacements of the principal tectonic plates for over a decade already. And they are using two methods—**satellite laser rangefinding** (Lageos satellites with reflecting prisms) and **very long baseline interferometry** (extragalactic radio sources are used). The first method can be used to determine absolute rates of movement of plates on which laser rangefinders are placed and relative rates (changes in the length of a line connecting observation points, and components of coordinate axes). Relative rates of plate displacement are determined by this method today with a precision of 0.3-1.0 cm/year (the plates themselves move at a rate of up to 10 centimeters a year). In the meantime, the absolute rates of movement of plates are estimated at values that are 100 times less precise.

The method of very long baseline interferometry makes it possible to determine only relative rates; the level of precision of the results is approximately the same as with laser measurements.

A rather large number of determinations of the rates of movement of lithospheric plates have been made by both methods within the framework of NASA's scientific project "Dynamics of the Earth's Crust" and the Wegener project consisting of a consortium of European geophysicists. But it is premature to discuss these results in detail, inasmuch as the time interval for which processed information exists is less than five years (1979-1984). The African plate has not yet been "tied in," and specific measurements have not yet been made of the rates of displacements of the Indian and Euro-Asian plates where they contact and of the movements of the Arabian plate relative to the Euro-Asian plate (all of which is of extreme interest to scientists). Precisely determined absolute rates of at least some of the plates would be of exceptional importance.

All of that has yet to be done, but it is already clear today that development of the methods of satellite geodesy provides scientists with a unique opportunity for studying deformation of the Earth's lithosphere on a global scale and for analyzing those deformations with a precision previously unavailable—10^{-8}-10^{-9} However, we should note that the apparatus used in both methods is still rather cumbersome, even in its mobile and transportable forms, and it is expensive. That means that it cannot be used very widely. Which is why thought is being given to global satellite systems containing highly automated ground stations for receiving satellite signals as the principal means of studying deformations and mutual displacements of blocks of the Earth's crust, and especially for **monitoring deformations**—continuous tracking of deformations for the purpose of obtaining data for predicting earthquakes.

A 'Constellation' of Satellites

Precise satellite navigation systems began to be developed back in the late 1960s and early 1970s. Several of them are known today. A unique constellation of artificial Earth satellites—bearers of precision time and spatial coordinates that are transmitted by radio link to Earth—is being created in near-Earth space. Among such systems we can name America's **NAVSTAR,** the Soviet **GLONASS**, the European space agency's **NAVSAT,** and West Germany's **GRANASS** (abbreviations of the same name, "Global Navigation Satellite System"). The Soviet and American systems are currently functioning in an experimental phase, while the latter two exist only on the drawing boards. The **NAVSTAR** system will include 24 satellites (21 working and 3 backup), and the **GLONASS** system will have the same number of satellites, with the same ratio of working satellites to backup.

Complete deployment of the system is slated for 1992 for the **NAVSTAR** system and 1995 for the **GLONASS** system. In addition to specialists in navigation, many geodetic, geological and geophysical organizations were enlisted in the development of the American **NAVSTAR** system in the early research stages. Today, for that system, a number of companies are manufacturing precision receivers that have already undergone field trials. Original methods have been developed for measuring deformations of the Earth's surface, the software has been prepared, a number of geodetic production projects have been completed, and studies of the deformation of the Earth's crust are under way (United States, Japan, and China).

As for the Soviet **GLONASS** navigation system, geodesists and geophysicists have yet to complete a certain stage of its development. And the greatest difficulties here are those of organizing industrial manufacture of precision geodetic ground receivers. The technical capabilities for manufacturing receivers capable of receiving signals from satellites of both systems have already appeared. More than 10 satellites of the **GLONASS** system have been placed into orbit thus far. Coded signals that modulate a high **carrier frequency** produced

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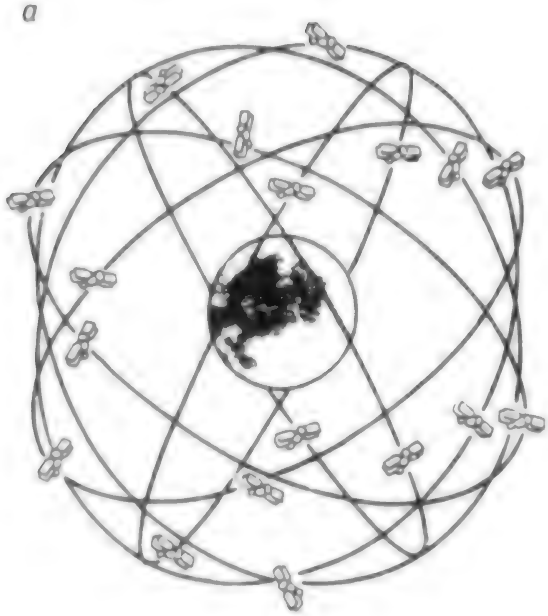

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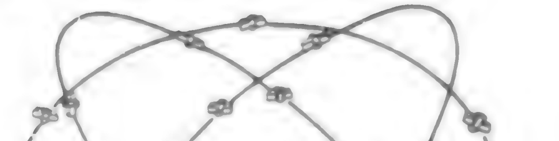


Space complexes of the (a) NAVSTAR and (b) GLONASS navigation systems. Satellites of the NAVSTAR system move in six planes, those of the GLONASS system move in three. The circular orbits of satellites of both systems have altitudes of 20,000 km and 19,100 km, respectively, and orbital inclinations of 55° and 64.8°

by a satellite-borne generator are used in it to make navigation determinations in real time. That frequency changes from one satellite to another, making it possible to distinguish the signals of the different satellites. (Note that all satellites in the NAVSTAR system have the same nominal frequency, but the way in which the oscillations are polarized differs to permit identification of the satellite.) The accuracy in determining the coordinates of points on the ground with one carrier frequency in the navigation measurements is 100-150 m for both systems.

On the Earth's surface, however, geodesists make their principal measurements not with modulated signals but with the carriers. For that, modulation is initially "erased" in the receiver, and the difference between the phases of the carrier frequency coming from the satellite and the frequency produced by the receiver generator is recorded on magnetic tape. In one series, the satellite is tracked for 0.5-3.5, hours depending on the orbit.

In the experience of American geodesists, when several series of measurements are taken with two carrier frequencies of 1600 and 1200 MHz (the second frequency makes it possible to determine the actual velocity of propagation of the radio signal in the ionosphere), the absolute coordinates of a point can now be determined with an accuracy of 3-5 m. On the other hand, relative coordinates are determined with accuracy not worse than 0.5-1.5 cm at distances of 5-15 km between points. Consequently, global satellite navigation systems can already be used for broad-scale studies of deformations of the Earth's crust, and they can be used much more effectively than can ground methods.

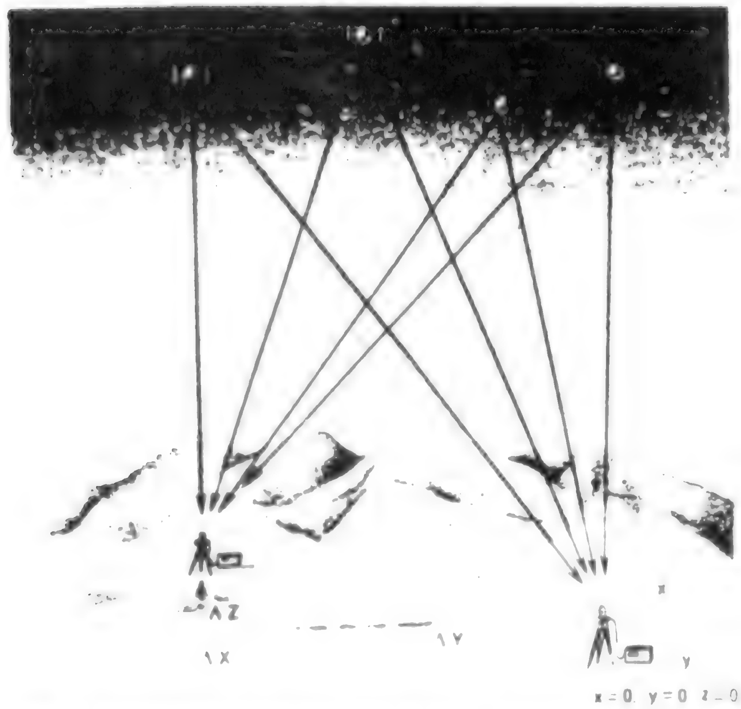
Monitoring Deformations of the Earth's Crust

Calculations by seismologists and field observations by geodesists show that intraplate deformations outside a zone in which earthquakes are preparing to happen are 10^{-8}-10^{-7} (1 mm per 100-10 km). Within the foci, on the other hand, before the seismic shocks occur, deformations grow strongly, and just prior to an earthquake they may attain 10^{-5}. Anomalous deformations that exceed background values (they may can be considered a predictive sign) manifest themselves 1-6 months before earthquakes of magnitude of 5-6 and several years before earthquakes of magnitude of 7-7.5. The linear dimensions of zones in which such abnormal deformations occur are tens and sometimes even hundreds of kilometers.

In light of the fact that deformations develop slowly and the process is nonlinear, the determination accuracy (within a 2-3 hour measuring cycle) needs to be at least 10^{-7} when the distances between points are 5-15 km. What that means is this: to solve the problems associated with monitoring deformations for predictive purposes, we must raise the accuracy of determining relative coordinates by at least an order of magnitude above what is now possible with a system like NAVSTAR-GLONASS.

Analysis shows that when multisatellite systems are used for absolute and relative determinations, the principal errors occur as a result of instability of satellite generators and uncertainty of satellite orbits. To mitigate those phenomena, geodesists are forced to complicate the observation procedures and the data processing and introduce additional unknowns into the equations used for the processing.

We can eliminate all of these difficulties in the future by using **coherent (phase-matched) signals**, in which the satellites exchange carrier frequencies among themselves, as a result of which coherent carriers, on which the geodetic measurements are also made, travel from



Determination of the relative coordinates of two points from satellite observations. The unknown coordinate differences (ΔX, ΔY, ΔZ) are functions of the distances to the satellites (measured synchronously from the end points of the line connecting the observation points) and the coordinates of the satellites

the satellites to the observer. With a system for monitoring deformations of the Earth's crust, it would be sufficient to switch only three or four of the 24 satellites to "coherent mode," without losing them as navigation satellites. In that case, the requirements on the stability of satellite generators decrease by almost three orders of magnitude for absolute determinations and two orders of magnitude for relative determinations. When coherent signals are used, the satellites can employ rubidium and high-quality quartz generators in place of cesium and hydrogen generators, which are heavy and expensive at that. This simplifies the space complex considerably, especially in light of the fact that three generators are called for on each satellite for the sake of reliability.

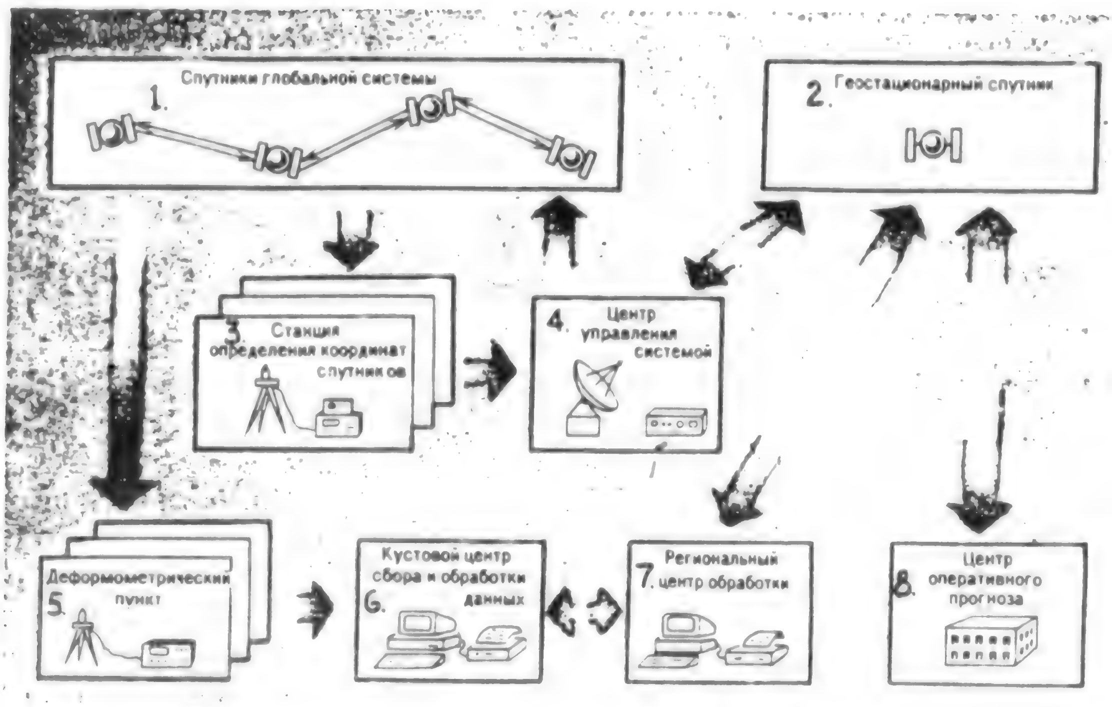
One other attractive side of using coherent signals is the capability they provide for ground-based precision measurements of distances between satellites. Such data also help to raise the accuracy of both satellite ephemerides and ground point coordinates.

Thus, satellite geodetic deformation monitoring methods have substantially greater capabilities than do ground-based methods. And not just from the standpoint of rapid operations (they are no less than five times faster than ground-based methods) and the capacity for increasing the measurement repetition frequency all the way up to monitoring mode. Satellite methods provide higher accuracy (by an order of magnitude), and they permit measurements of both deformation components—vertical and horizontal—from the same complex of measurements. No less important is the fact that deformometric points on the Earth's surface may be selected at places that, from the geophysical standpoint are of greatest interest, and where it is sometimes simply impossible to reach with geometric leveling. The mutual visibility of the points whose relative shifts are studied that is mandatory in ground-based measurements becomes entirely unnecessary. The "all-weather" capability of satellite measurements may become the decisive factor under certain conditions.

Calculations show that when a coherent satellite monitoring system is used over large areas, we can also study the components of the main rates of deformations, shear deformations and dilatation (volume deformation) of the Earth's crust with higher accuracy (0.5-1.5 x 10⁻⁷). Thus, we can formulate the objective of monitoring. First, using measurements made by a satellite deformation network in three successive epochs, we need to **approximately** determine the coordinates of the earthquake focus, the magnitude of the impending seismic event and the time at which it will occur. Then we need to continuously **refine** those parameters as monitoring data accumulate and contributions of information are made from other disciplines.

The Monitoring Service

When the objective is to create a **Service for Monitoring Deformations and Movements of the Earth's Crust for Earthquake Prediction,** then, along with the deformometric complex itself, the problems of effective transmission of information to forecast centers acquires great



Functional diagram of a satellite system for monitoring Earth crust deformation.
Key: 1. Satellites of the global system—2. Geostationary satellite—3. Station for determining satellite coordinates—4 System control center—5. Deformometric point—6. Cluster data collection and processing center—7. Regional processing center—8. Rapid forecast center

significance. That applies to transmission of all forms of prognostic information from the territory under study. In light of the immense overall flow of information, it would be advisable to use multifunctional **geostationary satellites.** Two geostationary satellites will have to be used for the system working over our country, while three satellites would be needed for a worldwide system, which is something we need to strive for.

The the deformometric measuring complex of the future will include all the satellites of the **GLONASS** and **NAVSTAR** systems, with three or four operating in coherent mode to permit monitoring in earthquake regions. The coordinates of those satellites are determined from the data of **SDSC** (station for determining satellite coordinates) points, with the use of the data of measurements of distances between satellites. Four or five "standard" satellite signal receivers that continuously measure deformations need to be set up in each of the earthquake regions (45 of them have now been selected in the USSR). In addition, the Service for Monitoring Deformations must have 5-10 receivers for "quick response"—for use in regions where the precursors of seismic events are manifesting themselves.

The initial field deformation measurements are collected in a cluster processing center and then transmitted by way of a ground communication system to a regional processing center. The regional center has a radio transmitter by which digital information is transmitted from one of the communication trunks via geostationary satellite to a rapid forecast center. It is there that an expert group uses the entire set of prognostic signs (seismological data, deformational data, data on the electrical resistance of rock, on the state of the ionosphere, on the height of the water table and on the concentrations of various gases in ground water) to arrive at a decision on the appropriate steps to be taken in connection with a possible seismic event.

Cosmonaut Suggests Drug Surveillance From Space

LD1909155490 Moscow TASS in English 1537 GMT 19 Sep 90

[By TASS correspondents Aleksandr Borisov and Igor Gvritishvili]

[Text] Moscow September 19 TASS—Soviet Cosmonaut Viktor Savinykh suggested that Soviet space equipment be used to search for drug plants. He was speaking today at the international seminar devoted to combating drugs, which is attended by customs officials from 31 countries

Savinykh, heading the Geodesy, Aerial Photography and Cartography Institute, believes "traditional methods of searching for drug plants are becoming less effective." He said the Soviet Union works to develop operative methods to discover illegal plantations, using remote sounding facilities.

Preliminary experiments have shown the highly efficient Soviet equipment allows to discover opium poppy plantations as small as 10 square meters wide.

The research is based on the study of drug plants' spectral reflecting characteristics and the possibility to use materials of multizonal and spectrozonal survey, received from board the aircraft and artificial satellites, he said.

Crews working on board the Mir space station are rendering great assistance in the elaboration of the method, Savinykh said.

Savinykh told TASS that "in the nearest future, we might expect an unprecedented spread of drugs in the world, and it is necessary to join efforts to combat drug trafficking."

The Soviet Union is ready "to sign an agreement with all interested organisations to ensure land and air spectrometering of drug plants, take photographs of any region of the world from aboard the manned space stations and artificial satellites and equip (an) air laboratory with special equipment," Savinykh said.

'Molniya-3' Communications Satellite Launched 21 Sep

LD2109080690 Moscow TASS International Service in Russian 0737 GMT 21 Sep 90

[Text] Moscow, 21 Sep (TASS)—To ensure the exploitation of remote telephone and telegraph radio communications, relays of USSR Central Television programs to the 'Orbita' network stations, and international cooperation, another communications satellite, 'Molniya-3' was launched by a 'Molniya' carrier rocket in the Soviet Union today.

The satellite has been placed in an orbit with the following parameters: apogee 40,782 km in the northern hemisphere; perigee 454 km in the southern hemisphere. The period of revolution of the satellite is 12 hours, 15 minutes, with an orbital inclination of 62.7 degrees.

Communication sessions via the 'Molniya-3' satellite will be carried out in accordance with a scheduled program.

'Meteor-2' Weather Satelite Launched 28 Sep

LD2909113190 Moscow TASS International Service in Russian 0753 GMT 29 Sep 90

[Text] Moscow, 29 Sep (TASS)—"Meteor-2," the latest meteorological earth satellite, was launched in the Soviet Union by a "Tsiklon" carrier rocket on 28 September 1990.

The satelite has been placed in an orbit with the following parameters:

—initial period of revolution, 104.2 minutes;

—maximum distance from the earth's surface (apogee), 975 km;

—minimum distance from the earth's surface (perigee), 953 km;

—orbital inclination, 82.5 degrees.

Sets of apparatus for obtaining global representations of cloud cover and the underlying surface in the visible and infrared ranges of the spectrum, both in memory and direct transmission modes, and of radiometric apparatus for continuous observations of flows of penetrating radiation in near-earth space are installed on board the satellite.

Besides scientific equipment the satellite has a system that ensures the satellite is positioned toward the earth; a system for electrical supply that has independent orientation of solar batteries toward the sun; a radiotelemetry system for relaying data on the work of the satellite's auxilliary systems to earth; a radiosystem for precise measurement of the orbit's parameters; a radiocomplex for relaying scientific information to earth.

The installed equipment on the satellite is functioning normally. A command-measuring complex is controlling the functions of the satellite. The information from the satellite is being relayed to the State Research Center for the Study of Natural Resources, and to the Hydrometeorological Center of the USSR State Committee for Hydrometeorology, for processing and utilization

'Gorizont' Communications Satellite Launched 3 Nov

LD0511091490 Moscow TASS International Service in Russian 0730 GMT 5 Nov 90

[Text] Moscow, 5 Nov (TASS)—In accordance with the program for the further development of communications systems and television broadcasting by means of artificial earth satellites, on 3 November 1990 the launch of another "Gorizont" communications satellite was carried out by a "Proton" carrier rocket in the Soviet Union.

The satellite has been placed in a near-stationary orbit with the following parameters: distance from the earth's

surface—35,688km; period of revolution—23 hours 51 minutes; orbital inclination—1.4 degrees

The apparatus installed on the "Gorizont" satellite is working normally. The command and measurment complex is monitoring the satellite. The satellite's communications and television apparatus will be used in accordance with the planned program.

UDC 629.78.004.6

Conversion of Rocket-Space Production Technology for the National Economy

907Q0118A Moscow VESTNIK MASHINOSTROYENIYA in Russian No 5, May 90 pp 3-7

[Article by V. A Isachenko, doctor of technical sciences, Scientific Research Institute of Machine Building Technology]

[Abstract] The conversion of defense industry resources, specifically the production technology of the rocket-space industry, to provide consumer goods and to serve the needs of the national economy in general is already under way, although further analyses and discussions are necessary to ensure its success. Some 28 basic technologies identified in the rocket-space industry are being directed by government programs and "Progress-95" to serve the needs of the following branches of industry: light industry and chemical fibers (thin-wall casting, rolling of precision blanks, deep drilling, protective metal coatings, etc.); health industry (precision casting and die forging of titanium, 12-channel thermometer, equipment for rehabilitation and restoration of motor functions, etc.); agriculture (metal spinning, vibration drilling, precision-investment casting of stainless steels, automatic welding, powder metallurgy, instrument hardening, etc.); construction industry (production control, specialization of production, precision casting, automatic welding of pipes and beams, etc.); machine building (thin-wall casting, restoration of parts, laser welding, production of ceramic plates, forming of pipe-fitting T's, etc.). The conversion of existing rocket-space technology is expected to have an economic impact of 420 million rubles in 1990. Making the technological potential of the rocket-space industry available to the national economy is to proceed in stages involving the transfer of existing technology and stocks to the national economy and the development of new technology with an eye to meeting national economy requirements, as well as those of space. The final stage will involve transfer of rocket-space enterprises to sectors of the national economy. By the year 2000, the economic gains from the conversion process are expected to exceed 2 billion rubles.

UDC 629.78.002.51/.62.004.6:061.4

Conversion of the Technology for the Production of the ENERGIYA-BURAN System in the National Economy

907Q0118B Moscow VESTNIK MASHINOSTROYENIYA in Russian No 5, May 90 pp 47-49

[Article by V. I. Grigoryev, candidate of technical sciences, Scientific Research Institute of Machine Building Technology]

[Abstract] An exhibit bearing the title "Conversion of the Technology for the Production of the Energiya-Buran System in the National Economy" is slated to open in 1990 at the Machine Building Pavilion of the Exhibition of Soviet National Economic Achievements. The organizational committee, under the direction of V. A. Isachenko, director of the Scientific Research Institute of Machine Building Technology, set two major themes for the current exhibition: first, the new procedural and organizational approaches to the development of complex systems and the new level achieved in technology, both of which facilitate breakthroughs in scientific and technical progress; and, second, results in the conversion of aerospace technology to serve the needs of the national economy. In terms of the second theme, the exhibit emphasized the gains to be expected in all sectors of the economy, from the food industry to medicine, as a result of the conversion of the technologies and skills used in the development of the Energiya-Buran space system. The exhibit consists of several sections, among which are ecology and resource conservation, information systems, production technology, quality control, organization of labor, automated planning of control programs, mathematical modeling in technology, and acceleration of production. A long list of spinoffs are noted, including large-scale precision-investment casting, thin-wall casting of aluminum alloys, titanium casting without the α-layer, and production of mold cores without toxic resin binders. In the development of the Energiya-Buran system alone, more than 300 new technologies have been developed and about 1,000 types of manufacturing equipment. The Scientific Research Institute of Machine Building Technology will cooperate with the Moscow Municipal Executive Committee, construction enterprises, and health care establishment to implement the "Progress-95" program. Analysis of the initial results of the conversion of the technologies and skills of the Energiya-Buran system to the economy indicates that almost all the advances realized in this space system can be utilized to raise the quality of production in the general economy to the world level.

Issues in Space Policy, Budgeting

907Q0099 Moscow NOVOYE V ZHIZNI, NAUKE, TEKHNIKE: SERIYA KOSMONAVTIKA, ASTRONOMIYA in Russian No 4, Apr 90 (signed to press 4 Apr 90) pp 3-49

[Annotation, table of contents and main text of book by Vsevolod Sergeyevich Avduyevskiy and Leonid Vasilyevich Leskov, "Where Is the Soviet Space Program Going?" Moscow, Znanie, 1990, 28,345 copies, 64 pages]

[Text] Annotation

The booklet discusses the prospects for the development of the Soviet space program and analyzes the possible ways and means for increasing its return to the national economy.

The booklet is intended for a wide range of readers.

Table of Contents

Does Today's Space Program Produce a Good Return?

Recently, calls have begun to resound in our press, on television and even from official rostrums to cut spending for the space program because of its poor return to the national economy. Are there really grounds for such criticism? Do we know how to use the available opportunities adequately enough? Are not the domestic programs for the development of the space program in need of a serious review? These are very serious questions. Not so very long ago, a thick shroud of secrecy almost completely concealed the affairs of the Soviet space program. As a result, it was reminiscent of an iceberg, most of which was hidden beneath the water, and it made even the very formulation of those questions pointless. Now the situation is changing rapidly, and the opportunity has arisen to delve into those questions, if only partially and incompletely for the time being.

Let us begin with the figures. In 1989, some 6.9 billion rubles were allocated in the USSR for space programs, 3.9 billion of which went for defense and science and 1.7 billion of which went for national economic purposes. The work on the Buran space plane comes to 1.3 billion rubles. These figures speak for themselves: it is clear that the multibillion-ruble expenditures for peaceful space that we used to write about are little more than a myth—in the country's national income, they amount to a total of 0.26 percent. For comparison, we would note that this amount is smaller by a factor of 10 than the expenditures of just the Ministry of Land Reclamation and Water Resources alone for the same year and smaller by a factor of 5 than the aid which the Soviet Union is rendering free of charge to other countries.

In the United States, in the 1989 fiscal year, the spending for space programs amounted to $29.6 billion, including $22.8 billion for Department of Defense programs, $3 billion for science and national economic purposes, and $3.8 billion for the reusable Space Shuttle space transportation system, which is being used for both peaceful and military purposes.

But what is the return produced by the space programs? Here are the official figures published in the United States: for each dollar invested in the space program, a profit of $7-14 is derived. American industrial companies willingly invest money into the space programs and compete for state contracts that ensure a high rate of return of the capital investments.

The profits obtained through the indirect use of the space program's advances, when they are applied in the national economy, are even higher. For example, the U.S. government spent $25 billion for the Apollo program, which enabled the American astronauts to go to the Moon, and the profits that American manufacturers received from the spin-offs of new materials, technologies and equipment developed in that program amounted to $225 billion.

The Soviet space programs relating the national economy are also paying for themselves, and the talk of their unprofitableness is groundless. For example, in 1988, revenues of around 2 billion rubles were received from the realization of those programs. It is important to emphasize the specific national-economy-related space programs for which a profit was obtained. According to the Ministry of Communications, the economic impact from the use of the Orbita, Ekran and Moskva satellite communications systems amounted to 540 million rubles in 1988. The satellite-based meteorology systems are making it possible to reduce the losses caused by natural disasters by approximately 500-700 million rubles a year. The combined research on natural resources conducted from space is producing an economic impact of 350 million rubles annually. According to the estimates of USSR Glavkosmos, in the near future, that figure will increase to 1 billion rubles. Space photographs, for example, are making it possible to increase the quality of geological surveys and to facilitate the search for new mineral deposits and are resulting in a reduction in the cost of regional geological prospecting operations by 15-20 percent.

Space-based map-making is giving us the opportunity to make the best choices in terms of the most economical

and ecologically safe versions of projects for municipal and industrial construction. At the same time, it is making it possible to reduce by a factor of 2-3 the spending for field surveys. According to the estimates, every ruble spent on making space photographs produced 5 rubles in profit.

As for the introduction of space technology advances into the national economy, the domestic space program has grand possibilities in that respect, too. Unfortunately, for now those opportunities are being used not nearly to the fullest extent. However, work in that area has recently begun to develop more vigorously as a result of the conversion problems addressed by the country's leadership.

The information cited here confirms that it is unfair to upbraid our space program for a poor rate of return and that the spending for peaceful space is paying for itself. But the same data indicate that there are still substantial reserves for a further increase in the return. It is particularly evident that, in terms of the space program's productivity, as defined by the level of profitability, we are lagging far behind the United States. Why is this happening, and what are the specific ways by which we can increase the rate of return of the Soviet space programs?

How Can the Space Program's Rate of Return Be Increased?

This discussion must begin with glasnost, because it is glasnost which is a preliminary mandatory condition for assembling the best space research programs and for promptly introducing the space program's advances into practice. This elementary requirement is well understood in the West, where all the space programs are publicized ahead of time and where not only specialists, but also broad circles of the public, participate in their evaluation. Decisions about their financing are also made quite openly on the basis of democratic parliamentary procedures.

A large number of scientific and popular science magazines and special publications on the space program's problems are published in the West. National and international forums and exhibitions are held regularly, and one of their main goals is the broad dissemination of information about the space program's latest advances and the organization of direct contacts between developers and potential consumers. Special firms and institutes are in operation whose main task is to transfer the innovations of space technology to Earth-bound consumers.

Things are different in our country. The domestic program for the development of space technology to be used for scientific and national economic purposes was published in an extremely condensed form in only a special advertising brochure put out by Glavkosmos, "The USSR in Space—The Year 2005," and in certain newspapers (for example, in the issues of KRASNAYA ZVEZDA for 23 and 25 August, 1989). The cost of this program for three 5-year plans is 40 billion rubles. Neither the Supreme Soviet nor its commissions have examined this program yet.

Not a single scientific or popular science magazine devoted to practical matters of the space program is being published in the USSR. The participation of Soviet specialists in international forums and conferences on space programs is extremely limited, and the reports submitted from the USSR represent, as a rule, only a small percentage of the total number of reports given.

The absence of glasnost, plus the fact that only a narrow circle of specialists and leaders can discuss programs and documents under consideration, is one of the reasons for a number of bad decisions of major importance which have become known recently and which have led to very substantial financial losses. For example, in 1989, reports were finally published in the Soviet press about the work involving the development of the heavy-lift N-1 rocket. If those operations, on which around 2.5 billion rubles were spent, had not been stopped by a willful decision in 1974 at the stage of the final tests, then we would not have had to start from scratch on the present-day Energiya launch vehicle.

As another example of such poorly considered decisions, we can cite the history of the Krasnoyarsk radar station. After lengthy talks with the United States, the Soviet government acknowledged that the construction of that station was a violation of the ABM Treaty, and it made the decision to dismantle it. "Poorly thought-out decisions are costly," Minister of Foreign Affairs E. A. Shevardnadze declared on the matter at the meeting of the Supreme Soviet on 23 October 1989.

It is significant that the last example pertains to the realm of our esteemed military department, although the press in recent years has also attempted to present this defense site as an exclusively national economic site. Something that is also a cause for concern is the startling acknowledgement heard in that same speech by Shevardnadze: "The whole truth was not immediately known to the country's leadership." It seems that the conclusion which our minister of foreign affairs proposes that we draw from this story is too mild. "Yet, all the same, there should have been questions," he said, "about what those who made the decision about the construction of the Krasnoyarsk station had in mind."

During all the years of stagnation, just as to some extent in the preceding period as well, the activities of our military space complex remained a sphere about which only vaguely encouraging statements were permitted in the press, statements consistent with the style of our pre-war slogans of the type "A Secure Border" and "We Do Not Covet a Single Inch of Foreign Soil." Now the situation has begun to change. We can now speak openly about the big mistakes and costly oversights committed here. One more example in this regard is the treaty in effect between the USSR and the United States on the destruction of medium- and short-range missles. There is

no doubt that this is a great victory for peace-loving forces, a victory that may be of exceptionally great importance for the future fate of all mankind. The signing of that treaty had a great economic impact: already, at the present time, the savings derived amount to 400 million rubles annually, and after the elimination of all the missiles, that sum will increase even more.

But, on the other hand, one cannot help but admit that the basis of the treaty on the medium- and short-range missles is the "Zero Option" proposed previously by the U.S. administration. If the then leadership of our country had displayed greater flexibility in their approach to the matter, the the country would have been spared the quite substantial financial losses it incurred by first installing the missiles on alert status and then carrying out a set of operations for their dismantling and destruction. If, while observing all the necessary requirements of secrecy, the formation of our military space concept had been of a more democratic nature, the likelihood of such oversights would have been considerably less.

The arms race, which lasted for many years, led to colossal and, to a considerable extent, unjustified expenditures of material resources and human labor. We would remind you that more than three-fourths of the U.S. expenditures for space programs goes for the solving of purely military problems. The Soviet Union's reaction to this challenge, for a long time, remained constant and consisted of maintaining parity in the entire set of missile-based weapons. Such an approach doomed our country to copying nearly all the steps taken by the opposing side in this field and led to new rounds of the wasteful arms race. Understanding this, one U.S. political leader time and again would make a frank acknowledgement to this effect: "That's splendid, we will leave the Soviet Russia without underwear."

The reflection of this concept of rivalry was the work developed in the United States on SDI—the Strategic Defense Initiative. The essence of that strategy consists in effecting the accelerated development of the United States's military space potential and simultaneously forcing the "backward" Soviet economic system to incur new, enormous expenditures which might be too much for it. We would remind you that plans calls for the overall spending for strategic programs in the United States in the coming decade to be $236 billion, including $50.3 billion for SDI research alone. It is the largest U.S. research program.

The Soviet Union's response to all these actions is unambiguous: we must have Armed Forces adequate for the protection of the country. However, in recent years, the USSR's leadership found a means for proposing a real alternative to the logic of the arms race, by promoting the concept of sufficiency and equivalent security for the opposing military blocs based on setting lower levels for all types of armaments. Let us recall M. S. Gorbachev's statement that, in response to SDI, we would not duplicate the American program, but rather, we would find another solution, adequately reliable and effective, but, at the same time, considerably less expensive. This new approach to the military aspects of the space program was greeted by ardent support and approval on the part of all the peace-loving people and is producing a basis for the expectation that the national-economy-related potential of space research will, as a result of this decision, receive new impetus.

How the Space Program Is Managed

The next matter involves the organizational structure of our aerospace industry. That structure was established right after the war and originally was supposed to provide the solution for just one solitary problem—under the most difficult post-war conditions, it was to effect the creation of a nuclear missile shield for the homeland as quickly as possible. One cannot forget the feat of labor of those who brilliantly managed the solution of this most important and historic problem.

Domestic missile construction, with the broadest support of the CPSU Central Committee and the Soviet government, was rapidly converted into a new powerful sector of machine building. As a result, by 1957, the Soviet Union became one of the world's leaders in the field of launch-vehicle and spacecraft development, even though similar operations were begun at the same time in the Western countries under more favorable conditions.

The Soviet Union's preeminence in the field of cosmonautics was demonstrated by the launch in 1957 of the first artificial Earth satellite and the flight into space in 1961 of the planet's first cosmonaut, our fellow countryman, Yu. A. Gagarin. Those events marked the beginning of a new era in the history of mankind—the era of the use of outer space in the interests of civilization. The egress into space opened up for humanity a fundamentally new opportunity for the construction in near-Earth orbits of an information-and-production infrastructure based on the broadest and most comprehensive use of outer space for scientific and national economic purposes.

However, in subsequent years, the situation gradually began to change. In the United States, enormous sums of money were appropriated for the development of an aerospace complex. In order to demonstrate the capabilities of its country to the whole world, the U.S. administration set as a national goal the flight of a man to the Moon. After receiving for such purposes a sum that was colossal for those times—$25 billion—the American specialists handled the task brilliantly: in July of 1969, Neal Armstrong became the first to step onto the surface of our planet's satellite.

The slowdown noted on the eve of the '70s in the rate of development of the Soviet space program continued. The Soviet Union carried out a number of high-priority projects for the study of outer space (the continuation of the Venusian research, the Vega project, the operation of the Kvant astrophysics module as part of the Mir orbital complex, and others). However, the successes achieved

abroad during this period in this area were of a greater scale in a number of respects. Here, one would mention the American Viking projects for studying Mars, the Voyager for studying the solar system's giant planets, and the Western European Giotto project for studying Halley's Comet.

The satellite communications systems used in the West are of a larger scale than are the Soviet satellites and, accordingly, produce a larger profit. The United States and the other Western countries have achieved great successes in the use of space-based systems for solving other national economic problems as well. In the process, the economic impact produced is, by various estimates, in the billions and tens of billions of dollars.

At the same time, the Soviet Union continued to play a leading role in manned orbital stations, an area fundamental to the space program as a whole. Here, a number of preeminent results were produced—for example, in the research involving the possibilities and conditions associated with long-duration manned flights in space—and the principles were developed for the design of a new generation of multimodule orbital complexes based on the Soviet Mir station.

That the Soviet space program was "running in place" became obvious when, in 1974, by the willful decision of L. I. Brezhnev and D. F. Ustinov, the work on the N-1 heavy-lift rocket was stopped. Typically, the entire world knew about the work on that rocket, about several failures during its testing, and then about the curtailment of further work. If one were to judge by the popular folklore that flourished during those years, the Soviet people also knew full well about everything. It was only our press which bashfully pretended that nothing of the sort was occurring. The first articles about this entire affair appeared in our newspapers only in the fall of 1989—on the 15th "anniversary" of the unfounded decision which was made privately and in deep secrecy.

The departmental structure and the management system in which all important decisions, without exception, are made only at the very top, acquitted themselves poorly in the initial stage of the establishment and development of the space program. The Soviet public was assigned a single solitary role—the role of enthusiastic listeners of TASS reports about the routine successes of the domestic space program. They preferred not to talk about the breakdowns and failures which are inevitable in any large venture. This suited many of the leaders, since it eased the pressure of possible critical comments aimed at them.

April of 1970 comes to mind in this connection, when the American Apollo 13 craft, with astronauts J. Lovell, J. Swigert and F. Haise on board, suffered an accident while going into near-Earth orbit. The planned flight to the Moon became impossible, and there was a real danger of the astronauts dying. The mass media immediately informed the country about this. The response of the American people was impressive: offers of help came from all sides, and a lot of practical suggestions were received. The entire country rallied and was thinking about how to save the astronauts. The ground services supporting the mission functioned splendidly. The crew of the spacecraft displayed great courage and a high degree of professionalism. As a result of all the efforts, a catastrophe was averted, and the craft returned safely to Earth. Yes, it was a failure. But at the same time, it was also an example of how, with the proper organization of affairs, even a failure can work in one's favor.

Soviet history also knows such examples. Suffice it to recall the epic poem "Chelyuskin" or the removal of Papanin's camp from the ice floe. It is a pity that the Soviet leadership, for some time, considered it preferable to solve such problems in deep secrecy from its own people.

Gradually, the administrative-command system, under the jurisdiction of which even the space program found itself, began more and more to retard its natural development. The N-1 rocket affair was one of the first graphic lessons of the situation that had come about.

To an ever greater degree, a whole series of shortcomings inherent in the organizational structure of the space science-and-production complex was becoming more evident. Enterprises that had large workforces and that were difficult to control had been formed, and it was no simple task to refocus them to deal with newly emerging tasks. Departmental barriers were erected between the Ministry of General Machine Building's space services and the enterprises of the national economic sectors—the consumers of space information.

In a number of instances, those enterprises were simply technologically unprepared to use the space information to really good effect in their own work. The corresponding services of the ground complex lagged behind, and there was a dramatic lack of computer equipment. The electronic equipment, which was based on the products of the Ministry of the Electronics Industry, was below world standards in many of their characteristics. This led to an unwarranted increase in the mass of space systems and to limitations in terms of their stints of active service lives.

As for the transfer of new materials, technologies and equipment developed during the performance of the space programs to other sectors of the national economy, it was hindered by a whole series of barriers: excessive secrecy, the customary absence of glasnost, the lack of information, the absence in the Ministry of General Machine Building of a direct personal interest in transferring the advanced experience it had garnered, and the absence in other departments of a direct personal interest in using it.

The difficulties encountered by the domestic space program, increasing year after year, were aggravated by the unwarranted "politicizing" of the program's successes, a politicization which the individual Soviet leaders began

to abuse. N. S. Khrushchev, who had intended "essentially to build" a communist society by 1980 and to have surpassed by that year the U.S. level of industrial production, stated that the process of "overtaking" our Western competitors would be gradual in various aspects and that, in rockets, for example, we had already passed them. Following his example, it became a customary practice to win new space victories, no matter what the cost, by various holidays and significant dates. That practice made it possible for D. F. Ustinov, L. V. Smirnov, and other leaders over the course of many years to report personally to Leonid Ilich Brezhnev about the latest success.

Recently, Academician V. P. Mishin, first the deputy and later the successor to S. P. Korolev as head of the design bureau now known as Scientific Production Association Energiya, cited examples which showed graphically what kind of losses the practice of such "willful decisions" led to. We have already mentioned the ill-considered cessation of the work on the N-1 heavy-lift rocket. Here is one more example: at the insistence of D. F. Ustinov, the work on the promising design of the Salyut-6 orbital station with two docking assemblies was canceled.

Let us compare the situation that came about in the domestic space industry and the organization of space research abroad, first of all in the United States. State financing of the space programs for scientific and national economic purposes is implemented there through the National Aeronautics and Space Administration (NASA), while military programs are financed through the Department of Defense. Space program projects are reviewed first by the National Space Council, which is chaired by the vice president of the United States, and then the administration submits them to congress, which, after discussion, annually approves NASA's budget and that of the Department of Defense. NASA spends part of the allocated monies on the maintenance of its own equipment and part on the space research centers and test ranges directly subordinate to it, but the main portion goes for contracts with industrial firms—the developers of space technology. The contracts are let strictly on a competitive basis. A large company that has received a state contract acts, as a rule, as a subcontractor in relation to other industrial companies or research organizations.

Working along with the large industrial companies that are part of the U.S. aerospace complex (General Dynamics, McDonnell Douglas, Rockwell International, Boeing, Westinghouse, General Electric and others) are a large number of comparatively small enterprises. This gives the entire system of management of operations considerable flexibility. Another feature of the American space programs consists in the fact that the number of people engaged in carrying them out in the various organizations can be rapidly changed in one direction or the other, depending on the volume and specific nature of the work.

One more important distinguishing feature of the American programs for space research is the extremely broad use of international division of the labor. Involved in the development of American space equipment are industrial companies and scientific-technical centers that possess advanced technology, regardless of their national affiliation. In order to effect some of the large space programs, international consortiums with joint capital are established. Such consortiums, for example, are operating communications satellites and satellites for the study of natural resources.

In addition to the work done on state contracts, some industrial companies perform scientific research and design work at their own expense. For example, the American company General Electric is working jointly with the West German concern Messerschmitt-Boelkow-Blohm on the development of an autonomous satellite-platform for conducting manufacturing experiments in weightlessness in the interests of industrial client-firms. The placement of the satellite-platform into a near-Earth orbit is planned for 1992.

International cooperation in the performance of various space programs has become a widespread practice in other countries as well. For example, recently, Brazil and the PRC established a joint firm which proposes using Chinese launch vehicles and Brazilian ground tracking stations. The goal of this firm is to offer to the international space systems market to launch satellites for various purposes with the Chinese Great Wall rockets for comparatively low prices.

What We Can Learn From Others

In comparing the organizational structure of space research in our country and in the United States, it may be noted that the latter possesses a number of important advantages:

- the considerably more open nature of the space programs, and the free access to all information, with the exception of military and technology secrets
- the much more democratic nature of the procedure for making key decisions
- the direct personal interest of the developers of space technology in transferring the advances they make into other fields of industry
- the competitiveness of the work, and the selection of projects on a competitive basis
- the flexibility of the main production structures, and the relative simplicity in switching labor and material resources to new tasks
- the more efficient hierarchy for managing functions, and the delegation from those at the top to those below of a wider range of authority to make decisions
- the efficient use of the international division of labor

- the more rapid use in space equipment of the innovations of the scientific-technical revolution

This list looks so impressive that it automatically brings a question to mind: then, in that case, just what was it that enabled the Soviet space program to win the leading role in the very beginning and to maintain it for many years? A number of things contributed to it. Without a doubt, the primary reason is that it was in our country that the founder of cosmonautics—our great countryman, K. E. Tsiolkovskiy—lived and worked, as did such world-class specialists as Yu. V. Kondratyuk, F. A. Tsander, and A. A. Shternfeld. Our country was also fortunate because the work of the pioneers of cosmonautics was continued by first-rate engineers and designers headed up by the founder of practical cosmonautics, S. P. Korolev, the brilliant mathematician and organizer of scientific research, M. V. Keldysh, and their talented comrades and colleagues, such as G. N. Babakin, V. P. Barmin, V. P. Glushko, A. M. Isayev, V. P. Mishin, N. A. Pilyugin, M. F. Reshetnev, V. N. Chelomey, and M. K. Yangel

An important role was played by the Soviet government's understanding during the post-war years of the need for developing a nuclear missile shield as quickly as possible. In the initial stage of the space program's establishment, solving this problem was possible with the methods of maximally centralized control that are inherent in the administrative-command system. And one more factor that played an exceptional role in the establishment of the Soviet space program was the work enthusiasm, the high degree of professionalism, and the devotion to their work among the rank-and-file laborers in our space industry, among the workers and engineers, among the designers and mathematicians, and among the executive officers and leaders.

However, the scale and nature of the problems to be solved changed as space equipment developed. The ways in which the organizational structure of the domestic space program was inferior to the foreign space program began to play an increasingly significant role. The signs of lagging gradually began to pile up. The rate of return to the national economy by space research turned out to be markedly higher abroad than it was in the USSR.

It would, however, be a mistake to believe that everything is bad in our country, while everything is good in theirs. On the contrary, the "structure" of space research abroad is characterized by a number of serious defects. The arms race, which has continued almost uncontrollably for the entire post-war period, casts a large shadow on the space program.

Furthermore, there is, at times, excessive "politicizing" of the space programs, and a disproportionately large emphasis is placed on the publicity associated with them. For example, to a large extent, the Apollo program had high priority, and its basic goal consisted of having American astronauts reach the Moon before the Russians

The organization of space research in our country has, thus, substantial shortcomings, which are directly reflected in the return made by the research to the national economy. In making it a goal to eliminate those shortcomings, much that is valuable could be learned from our foreign colleagues. At the same time, naturally, it must not be forgotten that their decisions are also far from ideal.

The Space Program and Perestroyka

After 1985, when our country entered into the period of perestroyka, a number of important decisions were made that were aimed at correcting the situation in which the domestic space program found itself. Above all, there appeared the opportunity to have a direct and frank discussion about the actual situation in a much more open manner than had been possible not that long before and to cite figures and facts previously concealed behind the seven levels of classification. This is already a big step forward and a good sign of the changes that are taking place.

Glasnost has reached such a level that, in August of 1989, shown on television was the expanded meeting of the board of the Ministry of General Machine Building, at which, in the presence of correspondents, the director of the Central Scientific Research Institute of Machine Building, Professor Yu. A. Mozzhorin, spoke about the draft of "The Program for the Development of Space Technology for Scientific and National Economic Purposes for the Period up to the Year 2000." While it is true that the first step has been taken, the second has not yet been taken—the program has not yet been published. One can get an idea about it only from fragmentary newspaper articles and from the Glavkosmos brochure.

Established in 1985 was Glavkosmos—the Main Administration for the Use of Space Technology for the National Economy, Scientific Research, and International Cooperation in the Peaceful Use of Space. Glavkosmos is offering foreign consumers the commercial use of various classes of launch vehicles—the Proton, the Soyuz, the Molniya, the Vostok, and the Tsiklon French, Indian and Czechoslovakian satellites have been sent into space by Soviet launch vehicles.

Being placed into a geostationary orbit is the Soviet Gorizont satellite, which provides all types of communications for the Intersputnik international organization. Foreign organizations are acquiring photographs of Earth produced from space by Soviet space vehicles. A program of research on general biological mechanisms which are the basis of the vital activities of man and other organisms is being carried out with the Bion satellites, with the participation of the countries of the socialist community, France, and the United States.

The Soviet Union—jointly with the United States, France and Canada—has placed into operation an international satellite system for rescuing crews of ships and aircraft that have had accidents. With this system, around 2,000 people have already been saved—

although, for the most part, they have been people abroad. Here again is the telling effect of the sadly set habit of our departments, which have at their disposal the Soviet Navy and Air Force, of not hurrying to equip their own units with the appropriate on-board devices. And without those devices, the space rescue service, naturally, cannot operate.

Interkosmos—the USSR Academy of Sciences' Council on International Cooperation in the Field of the Study and Use of Outer Space—has been in place in the Soviet Union since 1966. This council is entrusted primarily with the task of coordinating the work of the industrial ministries in their cooperation with other countries in the field of space research. Under the aegis of Interkosmos, a large number of experiments that were prepared jointly by domestic and foreign specialists have been carried out.

Most recently, the Soviet government granted to certain larger enterprises of the Ministry of General Machine Building the right to independently sign agreements on cooperation in space with other countries' organizations. All the measures should increase our country's activity in the international space market.

At the same time, a number of decisions were made that were aimed at the direct use of the production potential of the aerospace industry in the interests of the national economy and health care. For that purpose, a number of enterprises which previously were part of other national economic departments have been moved so that they are under the authority of the Ministry of General Machine Building. In addition, that ministry received a governmental assignment to develop modern equipment for enterprises such as bakery, soap-making, and sugar-refining enterprises. The manufacturing of prostheses and disposable syringes at aerospace enterprises is also under consideration. Agreements have been signed between the Komposit Scientific Production Association and the ministries of Health and of Installation and Special Construction Work and the Moscow City Executive Committee on cooperation in the manufacturing of new materials that were originally developed for the needs of space technology. Carbon carbon materials are being used to manufacture artificial tendons and to solve problems associated with endoprosthesis, and implants of high-durability steel, which was developed for rocket engines, are being used. New fire-resistant materials will be used for the panelling of metro and trolley cars. Ceramics have been proposed which will make it possible to manufacture faucets of a new design—water will not drip from them. If they are introduced in Moscow, then it will not be necessary to build the Rzhev reservoir, to which the ecologists are objecting so.

As can be seen, perestroyka has seriously touched the space program, and that, of course, is very good. At the same time, it is clear that much still needs to be done. Glasnost should stop being a half-way proposition. The numerous restrictions still remaining must be eliminated (while observing, naturally, all the necessary requirements of secrecy). In particular, the budget for scientific and national economic research in space should be made public and should indicate the specific expenditure items. The corresponding programs of operation should also be made public. The programs and budget for the operations for peaceful space should be approved by the Supreme Soviet in an open process.

Since 1989, there has been a considerable increase in the number of periodic publications. Unfortunately, our publishers, as before, are treating the space program like Cinderella: there has not been and there is still not a single journal devoted to its problems (not counting the highly specialized KOSMICHESKIYE ISSLEDOVANIYA and the KOSMONAVTIKA, ASTRONOMIYA series from the Znaniye Publishing House).

The International Space Market

Not everything is going well with international cooperation either. In the West, the internationalization of space research has become a fact. By contrast, centrifugal tendencies are, unfortunately, intensifying in the Interkosmos program. The newspapers have carried articles written by CEMA country specialists in which the specialists acknowledge that the Interkosmos programs have made it possible in the past to solve a number of interesting scientific and national economic problems, but they feel that the organizational bases of the programs now need to be reviewed. In particular, the opinion is being expressed that it would more advisable to construct these operations along the lines of the Joint Institute for Nuclear Research in Dubna: that is, to establish a joint center for space research headed by a council of directors—representatives from the participating countries—and with a common budget. The work would be carried out in a single program with the center's shared resources.

We must concede that there are definite grounds for considering the Interkosmos program inadequately efficient. We shall illustrate that by way of the example of the program for manufacturing experiments, which has been conducted on the Soviet orbital stations since 1978. A large number of experiments were conducted with the participation of specialists from Poland, Czechoslovakia, the GDR, Hungary, Bulgaria, Romania, Mongolia, Cuba, and Vietnam. Those experiments produced a number of interesting results. However, they produced almost no recommendations that could be used to improve the manufacturing processes developed in the Soviet Union for the production of materials in space.

Why did it turn out like that? The associates of the Interkosmos council and the USSR Academy of Sciences' Space Research Institute who conducted this work are competent, skilled specialists who know their business well. There are no grounds whatsoever for blaming them for the fact that, in practical terms, the experiments for which they were responsible turned out to be not very

successful. The cause here lies elsewhere—in the very principle underlying the organization of those operations: apart from the associates of Interkosmos and the Space Research Institute, the representatives from other organizations, which, it would seem, were interested in specific recommendations more than anything else, did not actively participate in drawing up the program of experiments or in conducting the experiments or in analyzing the results. If those operations had been carried out in a space center along the lines of Joint Institute for Nuclear Research, as our colleagues from the CEMA countries propose, then the situation would have been substantially different.

The entry of the Soviet space program into the international space market is also being complicated by a number of legitimate reasons. The first of them is the U.S. State Department's ban on the export of satellites in which American-made components are used to the USSR. Meanwhile, at the present time, around 150 satellites manufactured in the West are "awaiting" their turn for launch. Glavkosmos is prepared to guarantee that no one will touch them while they are in our country. Launching these satellites would be cheaper for the customers if Soviet rockets were used than if American or French insertion systems were used. However, the ban remains in place and is limiting considerably the practical possibilities of cooperation.

Another reason is of a more general nature and lies in the weakness of our country's foreign economic ties as a whole. In order to correct this situation, radical reforms are needed in the production structure,—including, to a some extent, the aerospace industry—plus a transition to a real market and a guarantee of the convertibility of Soviet currency.

The weakness of our foreign economic ties is also reflected in the program for the manned orbital stations, where we continue to hold a lead that is acknowledged in the West. At present, work is expanding in the United States on the development of the Freedom orbital station, the first version of which is scheduled to be launched in the mid-1990s. Western Europe, Japan and Canada—which are developing modules which will be part of the station and which are supplying equipment—are involved in financing the work on the station.

Western specialists are also displaying interest in the Soviet Mir orbital station, but that interest has been limited mainly to agreements involving visiting expeditions to the station by foreign cosmonauts. An eight-day visit to Mir by a foreign cosmonaut costs its sponsors $10-16 million. The goals they pursue are varied: the study of the Soviet experience in space research, the conduct of their own experiments, and publicity (the latter pertains to the scheduled flight of a Japanese journalist to the station, as well as that of a British cosmonaut, to a large extent). The foreign sponsors of space missions do not hide the fact that, after paying the Soviets the necessary expenses, they will be able to derive for themselves a large profit. Agreements have already been signed regarding flights on our craft by representatives from Austria, Japan, England, France and the FRG.

Unfortunately, except for the not very substantial hard currency receipts, which, in fact, barely cover our expenses for a joint flight, the Soviet side essentially receives very little from these types of joint missions. Meanwhile, the laws of the market, including the space market open the way here, in principle, for much more productive opportunities for cooperation. In fact, if our Western parters, in signing agreements with the Soviet side on conducting their own experiments aboard our space vehicles, thereby obtain access to the use of advanced technology which they themselves do not possess, then is it not natural for the Soviet side, by way of a fair exchange, to receive not only hard currency (and that much), but also some of the same "know how" associated with modern technology, which, in our time, is highly valuable in all the developed countries. In agreeing to a purely commercial solution of the matter, the Soviet side is running the ultimate risk of beginning to operate under the motto of the unforgettable Adam Kazimirovich Kozlevich, "Hey, I'll take it out for a spin."

Unfortunately, certain Soviet journalists have also thrown grease into the fire by starting, in our opinion, a scarcely serious campaign for sending one of their their own colleagues into space before the Japanese journalist. I would like to remind our journalists: the space program is too serious a matter to be turned into an arena of sports competition.

Departmental Barriers

Against the backdrop of the perestroyka, work is proceeding slower than one would like in the transfer of space technology to the national economic sector. Information barriers and psychological barriers are playing a large role in inhibiting those processes. One of us had the opportunity to talk time and again with people's deputies, party gorkom leaders and ispolkom leaders from many regions of the country, and important representatives of national economy departments at the exhibition of the scientific-technical achievements of aerospace technology, which was organized in 1989 at the Ministry of General Machine Building's Kompozit Scientific Production Association. The overall impression from these conversations is that recognition of the fact that the space program is not just TASS reports about the latest records, but also an inalienable and, for all practical purposes, very useful part of our daily life—recognition of that is having a hard time taking root.

As many people as possible must understand that the space program is for them—it represents, above all, new machines, materials, instruments, and technologies that can solve extremely efficiently many, many problems in machine building, construction, medicine and health care, and our daily lives. And even in sports: on display at the Kompozit exhibition were yachts, bicycles and

other sports equipment made from new materials that are durable and lightweight at the same time.

The impression is forming that the scale of the transfer of space program technology to the various sectors of the national economy will increase to an ever greater degree the actual capabilities of the Ministry of General Machine Building, which is the main department in the country directly responsible for the development and use of space technology. Apparently, it would be advisable to consider the question of a partial reorganization of space research, which could help remove the departmental barriers that are inhibiting the transfer of space program technology to the national economy.

Over the years of perestroyka, quite a lot has been done to increase the rate of return of space research. In 1988, the income derived from the peaceful items of the space program's budget exceeded for the first time the spending for them (let us recall the figures: 2 and 1.7 billion rubles, respectively). However, there is still a lot more to be done.

The State Space Program

In the determination of the most efficient ways of further developing the Soviet space program, an important place belongs to the State Space Research Program. What should this program be like? In summing up the results of the discussion of its project at the above-mentioned meeting of the expanded board of the Ministry of General Machine Building, Minister O. N. Shishkin said: "The state is not allocating money to us just because we drew charts and diagrams. Each enterprise of the sector needs to look for customers and a source of financing. Space must yield a return—that is the sector's strategy."

There is no doubt whatsoever that if the rate of return of space research is to continue to grow, the country absolutely needs the State Space Program. If that program is to be a real instrument for development, it must be discussed and approved from all angles at the highest level. The country's space program is not the business of just a single department, even if it is a large one like the Ministry of General Machine Building. It is the business of the country as a whole. Without such a program, the space program simply will not be able to move forward and, in fact, will be compelled to run in place, passing off as new achievements something like the above-mentioned flight into space of the first journalist, who would be our countryman. That is why it is very bad that we still do not have such a program.

Just what should a State program for the development of our space program be like? The authors have been involved with the problems of space research for many years. That gives them the right to express some personal views in this regard, views that, naturally, are arguable.

First, about the materials that can serve as a foundation for the discussion. First of all, of course, they include a brief presentation of the draft of Central Scientific Research Institute of Machine Building's program, which has already been mentioned above. It is a pity, of course, that, in the land of K. E. Tsiolkovskiy, who, more than 60 years ago, was the first person in the world to forumlate a program for the exploration and development of outer space, other such materials are lacking. But, unfortunately, those are the facts. Second, there include the foreign publications on this topic. In July of 1989, on the anniversary of man's first flight to the moon, President Bush gave a speech in the United States and he announced a new American program for the exploration and development of space. Prior to that, a number of space program projects designed at the state level or by private firms were published in the United States. Very interesting, for example, is the project published by Rockwell International in 1988, which involves an extremely detailed program for the exploration and use of space for the period up to the year 2100. All these and certain other materials will be used in our analysis.

In order to make the conversation more specific right off the bat, we will list the central points of NASA's program for the period up to the year 2000, along with the proposed spending:

- Reusable Space Shuttle Space Transportation System, including the improvement of its characteristics, the development of models, and operation—$55 billion
- Manned orbital station Freedom—$30 billion
- Aerospace plane—$10 billion
- Superheavy-lift launch vehicle with lift capacity of 45-70 tons—$8 billion

The spending for these four projects amounts, in all, to 60-70 percent of all the projected NASA expenditures for the years 1991-2000.

That program cannot be viewed apart from what other countries that are cooperating with the United States, as well as private firms of the aerospace complex and international space consortiums, are proposing to do over that same period. They are also planning serious operations: the development of economical launch vehicles, the development of autonomous orbital platforms for solving national economic problems, the conduct of experiments involving the transmission of microwave radiation from space to the Earth for the purpose of modeling a prospective energy-supply system for Earth, environmental protection and ecological projects, etc.

We will begin, if you will, with some general comments. It would be a mistake to make our domestic program simply a reflection of what they are proposing to do in the West. The world does not have two types of cosmonautics—Soviet and foreign. Cosmonautics is one entity. We must find our own place in this common process, and a dramatic intensification of our efforts in the world space market should play a leading role there. The

strengthening of our aerospace industry's foreign economic ties will facilitate the further growth of its rate of return.

The second a priori condition that must be laid down from the very outset pertains to the formulation of general optimization criteria that the domestic space program should satisfy. There may be several such criteria:

- support of a complex of strategic military tasks
- basic research on problems of astrophysics, planetology, terrestrial physics, etc
- solution of a complex of national economic engineering problems (remote sensing of the Earth, satellite communications, etc.)
- basic research on the problems involving new applied areas (space-based materials science and manufacturing, space-based power engineering)
- development of new classes of space transportation systems (the aerospace plane and economical launch vehicles)
- the direct application of the aerospace industry's potential to the solution of urgent national economic problems

Complete clarity exists only with respect to the first criterion: all the necessary steps to ensure the country's safety must be taken. Today, that means the realization of the concept of the sufficiency and equivalent security of the opposing military blocs.

As for the next group of criteria, their selection today is clearly dictated by the grave condition that the country's economy is in. It is perfectly obvious that priority must be returned, above all, to the further increase in the space program's contribution to the national economy in all possible areas. Quite a few examples have already been cited above of about how many reserves that we need to learn to use are still available here. The space program is a typical example of a system with limited resources (to put it plainer, with a strictly limited budget). The economists know well that, for such systems, a key condition for producing a maximum return is a well-drafted plan.

There is still one more special feature of the space program: its many engineering systems and projects, because of their high degree of complexity and uniqueness, are projects with an increased risk factor. Errors and failures are inevitable. On the other hand, in the event of success, a very large gain may be obtained. That is why the space programs absolutely must take into account the necessary element of equipment-related risk.

This special feature of space programs is taken into consideration in the West. In the first place, there the question of insurance for the space vehicles has been resolved—quite a lot of money is invested in their development and launching, and a failure can, in financial terms, turn into large losses for the developer. Unfortunately, in our country, that question has not been solved, which, in some instances, can complicate our relations with foreign partners. Second, the equipment-related risk is reduced as a result of the use of reusable space transportation craft, since their use means that expensive equipment can be repaired right in orbit or it can be returned to Earth for the same purpose.

Let us begin the specific discussion about the space program with the scientific research performed in outer space. Recently, academicians R. Z. Sagdeyev and K. Ya. Kondratyev and professors K. I. Gringauz and V. G. Istomin came out in the press with sharp criticism of the reasons for our lag in this matter. We do not intend to get into an argument with them. We would note only that here there is a simple way out of the situation: that portion of the space program's budget for basic scientific research (the investigation of the solar system, the ionosphere, and solar-terrestrial relationships, certain problems in biology, etc.) should be placed at the disposal of the USSR Academy of Sciences. The academy's specialists themselves would decide how best to spend that money—which priority objectives to select, how to organize international cooperation, and specifically what kind of order to give to the Ministry of General Machine Building.

The program announced by President Bush in the summer of 1989 outlined the sequence of the major steps to be taken in the exploration of space: the orbital station, the lunar base, and the preparation for a Mars mission. That program is meant to cover the period 2015-2020 and, according to estimates, will cost $800-900 billion.

The drafters of the American program propose giving it an international character. The Soviet Union has good experience in cooperating with the United States in that area—the joint flight in 1975 of Soviet cosmonauts and American astronauts in the Apollo-Soyuz Test Project. There is no doubt that all the participants, and cosmonautics as a whole, would gain from such cooperation in a new stage.

The publicized project for Soviet scientific research in space for the period up to the year 2000 also contains a number of interesting objectives. Among them is research in extra-atmospheric astronomy and research in space plasma and interplanetary space (the Relikt-2, Radioastron, and Koronas projects and others). The Lavochkin Scientific Production Association is designing the Spektr spacecraft for astrophysical research and the Solnechnyy Zond [Solar Probe] space-based laboratory for research in near-Sun space. Being developed is the Nika space vehicle, which will make it possible to investigate solar-terrestrial relationships and the processes in the magnetosphere and the ionosphere.

The next section of the future State Program consists of space-based systems to be used for national economy

purposes. In our opinion, it is this very section that should occupy a central place in the program. The geography and the nature and volume of services of the space market are continuously being expanded. It is expected that, by the year 2000, no fewer than 160 countries will be consumers of its output, while the contracts throughout the world will total several hundreds of billions of dollars.

In the Soviet Union, in the 13th and 14th five-Year plans, it is being proposed that a large volume of work be done in this area. Placed into operation will be space systems for national economic purposes with improved technical characteristics. We are talking about the future Granit, Gelikon, and Informator communications satellites. As of 1992, satellite relay of television programs is expected to cover the entire country. Satellites for direct television broadcasting to home receivers will begin operating. In the next two five-year plans, satellite communications systems are expected to produce revenues of 4.1 and 5.6 billion rubles, respectively.

Preparations are being made for the launches of new geodesic satellites intended for high-precision global and regional networks and for the determination of the parameters of the Earth's gravitational field. In the future, an accuracy in the tens of centimeters is expected to be achieved in the determination of coordinates. The work on space-based map-making will continue.

Slated to be placed into service are the future navigation satellites of the Glonass system, which will be made up of 24 satellites in three orbital planes, with 7-8 satellites in each (some of the satellites are backups). That system will be able to determine the coordinates of transportation vehicles to within meters and their speed to within centimeters per second. Work is being done to develop a more advanced Nadezhda-M search-and-rescue system. Future navigation satellites will produce an economic impact of 800 million and 3.8 billion rubles in the 13th and 14th five-year plans, respectively.

New geostationary Elektron weather satellites are expected to be placed into service and they will be equipped with television equipment operating in the visible and infrared bands of the spectrum. Such equipment will make it possible to determine the global distribution of the cloud cover on the illuminated and darks sides of the planet, plus the wind speed and direction at two-three levels of the atmosphere. According to estimates, in 1991-1995 weather and ecology satellites will provide revenues of 5.8 billion rubles, in 1996-2000, revenues of 9.6 billion rubles.

New satellites for studying the Earth's natural resources (Resurs, Okean, and others) are scheduled to be launched. They will result in practical recommendations for geology, agriculture, the timber industry, water management and the fishing industry, and for land reclamation, oceanography, and municipal construction. The use of those systems in the national economy is expected to produce revenues of 4.8 and 5.8 billion rubles in the 13th and 14th five-year plans.

Thus, in all, over a 10-year period (from 1991 through 2000), the enumerated national economic areas of space research will produce revenues of around 42 billion rubles. We would note that this figure does not include the profits that space-based map-making will provide—the authors did not have the appropriate data.

Space-Based Manufacturing

There also exist areas of the space program whose research is not yet completed, and the expected rate of return of those areas may therefore be determined only approximately. Let us dwell on three such areas—the space-based manufacturing of new materials, the development of a heavy satellite for handling the problem of establishing telephone communications for the entire country, and the project for transferring energy from space to provide an energy supply on Earth.

Let us begin with space-based materials science and manufacturing. The numerous experiments performed on Soviet unmanned and manned spacecraft, as well as those performed abroad, have shown that this is a promising area for the space program. In weightlessness, it is possible to produce semiconductor materials, biomedical preparations, glasses, and other materials with characteristics that exceed those of the best specimens obtained on the ground. The semiconductors and the biological preparations are very expensive—they cost hundreds of thousands and hundreds of millions of rubles per kilogram, respectively. That is why the additional costs required when they are produced in space may be recouped by substantially improving those materials.

One more thing: space-based materials science is one area of research in which the Soviet space program has maintained a lead. So that the reader will not suspect that the authors are being subject in their assessments, let us quote from the book "Fluid Physics and Space-Based Materials Science," published under the editorship of H. Walter in the FRG in 1987: "Despite the incompleteness of the appropriate information, it is obvious that the efforts in the USSR aimed at research on the problems of space-based materials science have been at least as significant as all the activities of the Western countries. A detailed analysis performed in the United States showed that the achievements attained in the USSR in the field of space-based materials science would require in the United States an increase in the level of financing of at least a factor of 4." For reference purposes, in 1987, some $78 billion were allocated from NASA's budget for research on the problems of space-based materials science.

Abroad, estimates of the economic return of space-based manufacturing have been made repeatedly. The published figures for possible profits lie in the range: billions or tens of billions of dollars a year.

But then a problem arises. The specialists in the field of space-based semiconductor materials science and space-based biotechnology have named the materials with which the transition to experimental industrial production should begin. The development of the units in which the manufacturing processes for the space-based industrial production of the materials can be perfected costs millions of rubles. But the space-based manufacturing of the materials also requires the development of specialized spacecraft. The design for one such craft has been worked out in the Soviet Union—it is the Nika-T unmanned spacecraft. The cost of the new space vehicles exceeds the cost of the equipment by about two orders of magnitude; in other words, we are talking about tens and hundreds of millions of rubles.

That is why the question arises, Who should finance this work? Until now, the development of nearly all space vehicles has been conducted at the enterprises of the Ministry of General Machine Building, with money allocated to it from the state budget. If the equipment-related risk proves worthwhile and the manufacture of semiconductors and biological preparations is begun in space, then who will receive the profits from their sale—the Ministry of the Electronics Industry, the Ministry of the Medical Industry, or some other department whose equipment is used to produce those materials? But that is not all. A department that receive unique semiconductor materials will produce equipment based on them, and the technical characteristics of that equipment will make it possible to sell the equipment for a high price. That, in turn, will provide the equipment's developers with an even larger profit: instruments are several times more expensive than materials. It is not hard to continue this chain for as long as desired.

Under present-day conditions, that is a very serious problem: the state order remains, but, at the same time, a profit has to be made, which is a market category. The resulting contradiction leads to the Ministry of General Machine Building not being economically interested in the development of space systems for the manufacture of materials, while other departments see no reason to contribute their own funds to the development of the systems—they are responsible for other, entirely different things.

How is this problem solved in the West? Several years ago, one of us discussed the organization of this work with L. Steg, who supervised the space research laboratory of the American company, General Electric, at that time. Steg formulated a simple and clear rule: "Scientific research is performed at the expense of the state, technology development is done at the expense of private capital." That is precisely how such work is organized in the United States and other Western countries. American companies have had opportunities to conduct experiments aboard space vehicles financed by NASA. However, when it comes to perfecting manufacturing processes, the companies conducting them have reimbursed NASA for the use of the Space Shuttle. That is what companies like, for example, McDonnell Douglas and Ortho Pharmaceutical did when they conducted experiments aboard the Space Shuttle in 1984 and 1985 on obtaining ultrapure erythropoietin—a highly effective agent for treating anemia.

The American companies that conducted the experiments and even trained their own astronaut for this purpose—C. Walker—spent a great deal of capital since they were counting on making $1 billion in profits within several years from the sale of the erythropoietin. In this instance, the equipment-related risk didn't prove to be worthwhile—because of the Challenger accident in January of 1986, the experiments were interrupted. The work was not continued with the resumption of the flights of the Space Shuttle in the fall of 1988, because, in the intervening period, competitors had mastered the manufacturing of pure erythropoietin on the ground.

Despite the equipment-related risk, American companies are spending considerable sums of money for the development of production equipment and unmanned orbital platforms designed for the manufacture of materials. Similar work is evolving in Western Europe, Japan and Canada. In order to garner experience in the space technology field and solve individual production problems (for example, growing protein crystals in weightlessness), the Western specialists are conducting experiments, on a commercial basis, on Soviet and Chinese spacecraft.

The development of new space vehicles is not inexpensive. For example, the unmanned ISF (Industrial Space Facility), a man-tended platform for the manufacture of materials in space will cost $600 million, according to the estimates of the American companies Westinghouse and Space Industries, which are developing the platform. The 10.8 kW output of the power plant aboard the platform is high enough to ensure profitable manufacture of materials. The transport operations will be provided by the Space Shuttle. The launch of the ISF platform into space is planned for 1991.

In light of the large expenditures required for the development of space systems, Western companies are pursuing the establishment of international consortiums to get the necessary capital. For example, more than 100 countries have formed the Intelsat international organization, which is engaged in the development and operation of a global satellite communications system. General questions of organization are decided by an assembly of the participants, while current questions are decided by a board of directors (the board is composed of representatives from countries countries whose shares exceed 1.5 percent). The largest shares are held by the United States (25 %), Great Britain (11%) and France (6%). The Intelsat system's ground stations are located in more than 100 countries.

Returning to the problem of financing the work on space-based manufacturing in our country, it is logical to ask whether it would be appropriate in solving the

problem to use the international experience and establish an interdepartmental consortium that would consist of Ministry of General Machine Building enterprises and other departments interested in the manufacture of materials in space. Such a solution would reduce the equipment-related risk for the participants in the work, would make it possible to select the best designs, and would ensure the personal interest of the various departments in the solution of a problem and a fair distribution of the profit received.

Telephones for Everyone

Let us examine the second new, promising area of space research—the provision of telephone communications for the entire country. In the Soviet Union, 15 million people are on a waiting list for the installation of a telephone. If, in the United States, there are 90 telephones for every 100 residents, there are 12 in our country. That is why we have a problem providing telephone communications—and it is one of the most acute of our problems.

Could we use future space systems for the solution of that problem? That question was discussed in May of 1989 at the meeting of the Presidium of the USSR Council of Ministers. The following project was proposed: use the Energiya rocket to place into geostationary orbit four heavy satellites, each weighing 18 tons (for purposes of comparison, the modern Gorizont communications satellite weighs 2.5 tons). It is estimated that a system made up of those satellites would be able to handle as many as 50,000 subscribers simultaneously, which would solve the problem of long-distance communications. In addition, a system made up of such satellites would open up new prospects in television broadcasting. The use of a space-based relay station would make it possible to transmit no fewer than 10 television programs.

In the West, the space communications problem is being solved another way: use is being made of small satellites equipped with high-quality electronics that last 10-15 years. Our electronics are extremely inadequate and limit the operating life of our communications satellites to 3-5 years. If an Energiya rocket with an additional upper stage is used, we will be able to place a heavy satellite into geostationary orbit. This will make it possible to effect "triple redundancy" of the system and, even with poor electronic equipment, possibly to increase the satellite's operating life to as much as 10 years.

In opposition to this undoubtedly interesting project have been the well-founded objections of the USSR Ministry of Communications. The proposed satellite communications system would relieve only negligibly the telephone "famine" that exists in the country. More satellites in geostationary orbit would not solve the problem: there is a shortage in that orbit—of space. And one more objection—an economic one: the Energiya rocket is very expensive to launch.

But even that is not all: our telephones and their telephones are two different things. They have dozens of different kinds, including radio telephones with an operating radius of dozens of kilometers and mobile telephones—in private automobiles, for example—that provide immediate communications with any point on the globe (excepts for points in our country, of course). One can get any kind of information over the telephone or order something from a store, after which the requested item is promptly sent to your home, etc. And all this with just a single solitary telephone; no one needs the dozens of telephones that adorn the desks of our leaders. None of these problems will be eliminated by space-based telephone communications.

In light of the problem's complexity, the USSR Council of Ministers, for the first time in the history of the domestic space program, is planning to hold a competition for projects for a future communications system. Regardless of the outcome of the competition, there is no doubt that the launching of heavy platforms into geostationary orbit will open up fundamentally new possibilities for solving a whole range of national economic problems.

As for the Ministry of Communications' attitude toward the proposal to use the Energiya rocket to solve the problem of providing telephone communications to the entire country, its leaders announced their own readiness to make a final finding on the project in 1990. Meanwhile, the problem of providing telephone communications to the entire country is being solved by ground-based means: the laying of new cable lines, the construction of automatic telephone exchanges, and the improvement of equipment. If 12.5 million communications lines are being placed into service in the 12th Five-Year Plan, some 22 million will be placed into service in the 13th.

Energy From Space

Let us examine now the third prospective area of the space program—the problem of supplying energy to Earth. About 10-15 years ago, a large number of articles were devoted to design studies on that matter. Proposed, in particular, were space-based solar power plants (SSPPs), which were to be located in geostationary orbit at an altitude of 36,000 km above the Earth's surface. A basic component of the SSPP is a system of solar batteries and other converters that transform the energy of solar radiation into microwave radiation that is transmitted to the Earth in the form of a well-focused beam. On the ground, the microwave radiation is caught by a receiving antenna, converted into a commercial-frequency electric current, and fed to the consumers.

The SSPP would have an electric output of [illegible]-10 GW and it would weigh around 50,000 tons. The diameter of the receiving antenna on the ground would be [illegible]-20 km. The frequency of the microwave radiation ([illegible] GHz) has

been chosen on the basis of the requirements for atmospheric transparence, while the density of the microwaves' power within the area of the receiving antenna (230 W/sq m) has been chosen on the basis of considerations of ecological safety outside the area.

The design studies performed in the Soviet Union and abroad have identified the advantages of SSPPs over other nontraditional energy sources: SSPPs are ecologically clean and safe; they conserve the Earth's mineral resources; they are self-contained; and, in the future, they will be economically competitive with other energy sources. These advantages were so appealing that proposals appeared in the United States for sending the first full-sized SSPP into space as early as the 1990s.

Later, however, objections were raised against haste in this process. The objections involved, mainly, economic considerations—the high cost of the transport operations for delivering the SSPP's components into space (for example, more than 1,000 flights of the Energiya rocket would be required) and the high prices for the energy converters. Those difficulties are, of course, extremely serious; but in the future, they may be overcome. Might this serve as the basis for the complete cessation of research? Apparently not. However, this research was wound down in the early 1980s in the United States and Western Europe. There has also been a clear drop in interest in the matter in the Soviet Union.

Let us compare the state of affairs regarding SSPPs and the research in another promising area involving the search for non-traditional energy sources—controlled thermonuclear reactions. Today, the situation in this area is such: the cost of the experimental plants of the mid-1990s is being figured in the billions of dollars. Here is the assessment recently given on the state of affairs regarding this problem by the head of the Soviet thermonuclear research program, USSR Academy of Sciences Vice President Ye. P. Velikhov: "We have to be honest and not deceive ourselves or others—we still do not have absolute proof that controlled thermonuclear fusion is technically and economically feasible." According to American estimates, the production of energy by the first commercial thermonuclear fusion reactor cannot be expected before the year 2020. Despite all these difficulties, research on controlled thermonuclear reactions is being financed in all the developed countries. And no one doubts that this is absolutely correct.

However, when the United States virtually ceased its own SSPP research, it lost, in fact, nothing; the work in that area was vigorously continued by its ally, Japan. Cosmonautics is visited by the international division of labor.

But the position of the Soviet Union as a result of the decision that was made turned out to be quite different—the possibilities for the formulation of our own approach to the problem were dramatically reduced. Meanwhile, the situation with energy resources in the country is quite strained. The possibilities for the construction of new hydroelectric power plants have almost been exhausted, the expansion of the network of nuclear electric power plants after Chernobyl requires a lot of caution, and the reserves of mineral energy resources are not limitless.

In Japan, for the period 1989-2005, plans have been made to implement a serious and well thought-out research program on SSPPs. In the first stage, in 1990, an autonomous platform with an 8-kW solar power plant is to be inserted into near-Earth orbit. That platform is expected to be used to test right in space the structure's basic components (the energy converters, the high-voltage solar battery, the electric rocket engines, etc.). The second stage, in 1997, will send a large platform with a 35-kilowatt power plant into space, and that platform will be used to conduct tests on the transmission of the microwave energy to the Earth and to the American Freedom station. The third stage (around the year 2002) will put a power plant capable of producing up to 10 MW of power into a geostationary orbit. For purposes of comparison, we would note that the power output of the world's first nuclear electric power plant, in Obninsk, was half that.

Why then, despite all that has been said, has research on the SSPPs not been supported in our country even with minimum financing, while it is continuing quite intensely in the West? It seems the basic reason is in the difference in the organizational structure of the space program.

In Japan, no fewer than 200 private firms, including such large concerns as Mitsubishi, are involved in the development of space systems. The Ministry of Trade and Industry is responsible for coordinating the work, while the state financing is being accomplished through NASDA—the National Space Development Agency. According to the statements of the Japanese themselves, their approach to space research corresponds to established traditions: initially, the goal is to assimilate the experience of others, and then it consists in moving forward in cooperation with the leaders in the sphere of cosmonautics. NASDA's budget for 1986 amounted to $620 million.

In the Soviet Union, the situation is fundamentally different. A state organization responsible for drawing up common space programs is lacking. Also lacking is centralized financing for the space programs drawn up by the departments. It is hardly surprising that, with that type of organization of work, the SSPP problem turned out to be in the position of an unloved stepchild: those who are responsible for space are not about to finance research on power engineering, while those who handle the questions of power engineering think just as rightly that space systems are not their specialty.

The situation, frankly speaking, is vexing. K. E. Tsiolkovskiy declared that "the chief goal of man is to capture as much of the Sun's radiant energy as possible." But his

successors, who consider themselves to be Soviet specialists in cosmonautics, have generally excluded that goal from their programs. Meanwhile, it is the Soviet Union that has abundant opportunities for experimental research on the SSPP problem. For example, it could use the Energiya-Buran transportation system for that. Recently, interest in cooperation with the USSR in that field was displayed by specialists from the Japanese Institute of Space and Astronautical Science.

The examples we have examined for the solution of three large national economic problems through the use of space systems—space-based manufacturing, telephone communications for the entire country, and the supply of power to the Earth—show quite graphically that, apart from its organizational difficulties, the space program is, to an ever greater extent, beginning to experience difficulties of an even larger scale—the scale of organization of the country's national economy as a whole. Those examples show that the present structure of the national economy—built according to the department principle and, in essence, as yet too little touched by the processes of perestroyka—may play the role of an obstacle to further growth in the rate of return of space research.

The way to surmount these difficulties should, perhaps, be sought on the path to the establishment of a single state organization that would handle the financing of scientific and national economic space research and would report directly to the USSR Council of Ministers and to the Supreme Soviet, which would approve its budget, and on the path to the creation of interdepartmental consortia established on a temporary basis to solve especially large national economic problems. The first step toward the establishment of this type of organization has already been taken—USSR Glavkosmos was established, and it is responsible for the organization of space research in the interests of science and the national economy. Perhaps, it would be advisable to take the second step as well, making Glavkosmos directly subordinate to the USSR Council of Ministers and commissioning it to prepare the proposals for the financing of the State Interdepartmental Program for the Peaceful Use of Space. The impression is also forming that the main way to actively link up our domestic space program with the international space market must be through scientific production associations, with the participation of foreign countries and companies.

The Coming Aerospace Revolution

In returning to the analysis of the prospects for the development of the space program, let us turn to the four main points of NASA's program enumerated above and continue to compare them with the draft of the Central Scientific Research Institute of Machine Building's program. Let us begin with points 1, 3 and 4 of NASA's program, which pertain to the modernization of the existing space transportation systems and the development of new ones. Altogether, the spending for those three points amounts to around half of NASA's proposed budget for the years 1991-2000—space transportation systems are very expensive.

The first point pertains to the Space Shuttle space transportation system, it use, and its improvement. In the Soviet press, that system has been criticized repeatedly and in every way possible. However, after the advent in the Soviet Union of the Buran space plane, which looks very much like the American "space shuttle" on the outside, puzzled voices began to resound from the pages of our newspapers, asking what was going on here.

There are major differences between the Space Shuttle and the Energiya-Buran system. First, in the Space Shuttle's case, there is no launch vehicle, engines have been installed directly on the orbiter, and the core unit is a pod-type engine unit. In contrast, the Soviet system consists of two independent items—the Energiya rocket, with a lift capacity of 105 tons, and the Buran orbiter.

Second, the Shuttle orbiter can fly only as a manned craft, while Buran can fly manned or unmanned.

Third, the Shuttle's first stage uses solid-propellant boosters, whose discharges are several thousands of times more destructive to the atmosphere's ozone layer than are the high-power fuels (oxygen, hydrogen, and kerosene) that are used in the Energiya rocket, which, in ecological terms, are considerably cleaner.

In developing the Space Shuttle, the American designers had tow things in mind: to reduce the unit costs for sending payloads into space and to ensure the return of those cargoes to the ground so that they could be used again. However, the need to send into space not only a payload, but also a spacecraft with a large mass (large, compared with an expendable rocket with the same lift capacity) meant that they could not solve the first problem. A Space Shuttle flight costs $300 million, and putting 1 kilogram of cargo into orbit costs $6,600.

In developing our Buran orbiter, the first problem was not addressed, inasmuch as the Soviet Union has a whole fleet of cheaper expendable rockets capable of inserting a payload of up to 20 tons into a near-Earth orbit (the Proton rocket). The second problem was addressed and solved.

The Energiya-Buran system brings fundamentally new possibilities to the Soviet space program. It enables the placement of heavy space vehicles into orbit and their check-out just prior to separation from the orbiter, the return to the ground of an expensive, unique materiel part, and, among other things, the assembly and erection of large structures in space. At the same time, it must not be forgotten that this is an extremely expensive system: 13 billion rubles were spent on its development, while the spending for Buran just in 1989, when not a single flight was conducted, amounted to 1.4 billion rubles.

It is not surprising, therefore, that work is being conducted intensively abroad on the development of space transportation systems that are considerably more economical. In the United States, primary attention is being devoted to two such projects—the aerospace plane and the Pegasus rocket, which will be launched from an aircraft.

Work on an aerospace plane is being conducted not only in the United States, but also in other countries—in the FRG, France, England and Japan. In the United States, the work is being performed in the National Aero-Space Plane (NASP) project. The aerospace plane is expected to be able to deliver a 9-ton cargo into a near-Earth reference orbit at a cost of around $1,000 per kilogram. For the aerospace plane's flight tests, three X-30 experimental aircraft are being developed. The development of the aerospace plane requires solving a large number of materials-science and manufacturing problems. The cost of the NASP program is estimated at $17 billion. It is being financed jointly by the Department of Defense, NASA, and private firms.

In the FRG, Messerschmitt-Boelkow-Blohm is conducting the work on the development of the Sanger aerospace plane. That aircraft is designed to solve two problems—putting the space plane (4 cosmonauts and a 4-ton cargo, or a 15-ton cargo) into space, and providing intercontinental flights at a hypersonic speed of around 5,000 km/hr. The Sanger aerospace plane's test flights are scheduled for 1998.

In France, Aerospatiale and Dassault-Bregnet, with the participation of around 100 French, German and Italian companies, are developing the Hermes orbital plane, which will be launched by the Ariane-5 rocket. The cost of the project is around $5 billion. The Hermes system will make it possible to perfect the principles of the aerospace plane and, in many instances, will also obviate the need to use the Shuttle as a transportation system. The interest being displayed in the aerospace plane in the West is perfectly understandable—the system has a number of important advantages: a dramatically lower cost for sending cargoes into space, the capability for a launch several hours after a launch decision is made, a horizontal take-off from a conventional airport, high frequency of the flights, and the expansion of the parameters of the orbits into which an orbiter can be inserted. These advantages of the aerospace plane as a promising transportation system are so great that people speak of its development as the advent of the second aerospace revolution.

Recently, the U.S. Department of Defense made the decision to reduce the allocations for the NASP project. In that connection, NASA is proposing the postponement of the construction of two of the X-30 aircraft for 4-5 years. The flights, then, would begin in about the year 2000. A decision about their construction is supposed to be made in 1990.

According to estimates, the cost of a single flight of the aerospace plane will be $9 million, and the cost of inserting a cargo into orbit will be $300 per kilogram, which is cheaper than using the Space Shuttle by a factor of 20. The aerospace plane will be able to perform 40-160 flights a year.

The main advantage of the Pegasus rocket, which is being developed by Orbital Science and Hercules Aerospace, is that it will reduce the cost of delivering cargoes into a near-Earth orbit to one-third of the cost associated with existing launch vehicles. The launch of the Pegasus is slated for 1995.

The development of new classes of space transportation systems will sharply expand the possibilities for solving many scientific and national economic problems. In evaluating the developing situation, which will exert a great deal of influence on the space market, one should note that, undoubtedly, the aerospace plane will also be widely used in solving various military problems.

One more class of new space transportation systems, the development of which is being conducted in the West, is the ALS heavy-lift launch vehicle with a lift capacity of around 70 tons. It is supposed to lower the cost of delivering cargoes into a near-Earth orbit to about $600 per kilogram. Participating in the rocket's development are the American companies Boeing, General Dynamics, Martin Marietta and McDonnell Douglas. The first launch is expected to be possible in 1996.

What is the reaction of the Soviet Union to these new developments? We already have a heavy-lift launch vehicle—the Energiya. The space-plane projects have long been of interest to Soviet specialists, too. One of the people overseeing the work on the development of the Buran space plane, G. Ye. Lozino-Lozinskiy, has proposed a winged reusable system in which the first stage would be the powerful Soviet Mriya aircraft, and attached to it as the second stage would be an orbital plane with an external tank. Such a system would be able to put a cargo of up to 7 tons into space in the manned version and up to 8 tons in the unmanned version. The external tank would be the only expendable component in the system.

The future will tell how things will actually develop. We would like, however, to express the hope that the Soviet Union—which was able to play a leading role in the first space revolution, which was marked by the launch of the first satellite and by the first flight of man into space—will also make a worthy contribution to the achievement of the second aerospace revolution.

Habitable Space

Let us shift to the projects for future orbital stations, which occupy a central place in the long-term American programs, because they are the projects that begin a chain of larger steps in the mastery of outer space by humanity: the new stage of lunar research, the lunar base, the study of Mars and its satellites, the mission to

Mars, the base on Phobos, and the base on Mars. In purely propagandistic terms, the development of cosmonautics, in the public consciousness, is associated primarily with that sequence of stages.

The Freedom orbital station being developed in the United States will be a grandiose multipurpose space complex. The station will be serviced by the Space Shuttle fleet.

The development of the first-stage orbital station is slated for the mid-1990s. Its assembly will require 10-11 Space Shuttle flights, and it will consist of nine sealed modules and a heavy-duty frame that will be 100-120 meters long and on which will be placed a 75-kW power plant. The station will weigh 180-225 tons. Over the course of the next 10 years of the station's use, there will be a gradual increase in the volume of the sealed modules (to 330 cubic meters from 110) and in the output capacity of the power plant (up to 375 kW).

In addition to the modules, the station's complex will include autonomous platforms not rigidly connected to it and located in various orbits. These platforms will dramatically expand the capabilities of the orbital complex as a whole.

The next special feature of the orbital station project is the fact that the work on it is being conducted within the framework of international cooperation. The countries of Western Europe involved in the station are developing Eureka-type autonomous platforms for experiments in weightlessness, their own sealed module, and, in the long run, their own Columbus station. Also developing their own modules are Japan and Canada, which, moreover, is designing the robot arm for assembly operations on the station.

There is no doubt whatsoever that manned orbital stations are needed—that has been shown most clearly by the USSR's experience in the operation of the Salyut and Mir stations. But here is the question: How justifiable are the characteristics of the American project, which are so high and are raising the price of its implementation enormously? Indeed, it means the curtailment of other urgent space programs, for which there is now not enough money. It is not surprising that objections to the project chosen for the station are being raised in the United States by such competent specialists in space research as J. Van Allen, who correctly noted that all the major discoveries in space have been made with unmanned, and not manned, spacecraft.

The American specialists who advocate the project have stated this: "Any discussion about the orbital station needs to begin with mention of the fact that the Russians have Mir." And so, once again, competition in the spirit of Twain's Captain Stormfield? It seems so.

Let us examine in more detail what specific problems the American specialists propose to solve on their orbital station. Here is a list of most of the objectives.

1. Performance of integrated basic, applied and manufacturing research.

2. Unique astronomical and astrophysical observations.

3. Servicing of satellites, assembly and repair of space vehicles.

4. Remote sensing of the Earth.

5. Use of the station as a space base, storage of fuel, payloads, etc.

6. Commercial manufacturing of materials.

7. Research in the field of space medicine and biology.

8. Servicing of missions to the Moon and Mars.

There is no doubt that this is a very serious program. However, many, if not most, of the objectives listed can be achieved with much cheaper unmanned spacecraft. The urgency of of other objectives—for example, the mission to Mars—is arguable.

However, the last thing we want to do is to be telling the American specialists which program for the research and development of space they should choose. All the more so since, according to the latest reports, the U.S. Congress is contemplating a substantial reduction in appropriations for the Freedom program. We are faced with dealing with a different problem: what our country's response to this new American challenge should be.

But, first, one comment of a general nature. We have already said that the American space program is an extremely profitable business. And we noted one important circumstance: the American companies receive most of their profits by using the space program's scientific and technical potential—which, for the most part, has been created with the taxpayers' money—to sharply increase the efficiency of the manufacturing processes in the most diverse sectors of industry. In the final tally, those same taxpayers (plus, of course, the companies of the aerospace complex) benefit from it.

That mechanism has worked out so well in their country that we would like to express one paradoxical thought: if the United States were to undertake the development of a perpetual motion machine—something that, of course, is absolutely impossible—then that project would also produce a large profit for them. That is because, in the course of the work, they would probably succeed in developing new materials, technologies, and instruments that would have numerous practical applications. That property of the Western economic system is proof of its great efficiency. We do not discount the fact that, in selecting their concept of an orbital station, the American scientists and engineers were guided, to some extent, by similar considerations.

The state of our economic system does not offer similar opportunities to the Soviet specialists. That is why they

must be guided primarily by the requirement of immediate success for the space programs. During the television broadcast already mentioned, Minister of General Machine Building O. N. Shishkin framed that thought with utmost clarity: if a proposed program does not satisfy the interests of society, and there is no demand for it, then it has to be abandoned.

In the field of manned flights and orbital stations, the Soviet Union is steadfastly maintaining world preeminence. And the American specialists are aiming to overtake our country in this field. The Soviet Mir station—the first of a new generation—has been in near-Earth orbit since February 1986, and its main distinguishing feature is the modular principle of its construction. That is the same principle that the Americans intend to use as the basis for their Freedom station.

Over the past four years, the Mir station has been the focus of a large volume of scientific and national economic research, and a number of new systems have been developed for supporting the operation of the station (a gyro-stabilized spacecraft attitude-control system that consumes no fuel; a unified attitude-control system; a new promising life-support system; and a "space motorcycle"). Operations have been performed in the assembly of solar batteries, antennas, and frames. Unique results have been produced in the study of the supernova 1987 A. A large volume of photographs has been taken on an order from the Priroda State Center. A number of cycles of new manufacturing experiments have been conducted.

Naturally, the question arises: in light of the large volume of research performed, is the Mir station paying for itself? The operation of the station is expensive. Here are published figures: the cost of the mission of A. Serebrov and A. Viktorenko, which lasted six months, was 90 million rubles. That means that the cost of keeping the Mir station aloft over the course of four years has amounted to no less than 360 million rubles, and that does not take into account the cost of developing it and experimentally outfitting it. Are those expenditures being recouped? A response to that question was given by Energiya Scientific Production Association General Designer Yu. P. Semenov, as he spoke on the Vremya program of 20 February 1989. The station has not yet paid for itself, but the onboard manufacture of semiconductors and biomedical materials in 1990-1991 is expected to bring a profit of 1 [illegible] rubles.

On [illegible] February 1990, speaking on that same program, Minister of General Machine Building O. N. Shishkin was more precise: in 1990, the profits will amount to 25 million rubles. What that figure will actually be will become known at the end of the year.

The Salyut-6 station operated in orbit for around five years, and the Salyut-7 station, for approximately the same amount of time. The Mir station has been operating since February 1986. It is to be expected, therefore, that the designers are getting ready to replace it with a new station. If that new station is launched in the next few years, it will most likely be a somewhat improved, modified version of the current station.

And how do our planners see the future orbital complex? Here is what is being reported on that matter in a brochure published by Glavkosmos: the complex will weigh 200-300 tons, its power supply will an output capacity of 150-200 kW, and it will have a crew of 9-12 people. The transportation operations will be performed by the Energiya-Buran system.

It is easy to see that our future orbital complex is in no way inferior to the American orbital station in terms of technical specifications. Also similar is the list of objective it is expected to achieve:

1. Basic scientific and applied research.

2. Servicing of space vehicles.

3. Erection and assembly of large space structures.

4. Development of components of new space systems for development of the Moon and research on Mars.

As is evident, the Soviet space program is not about to lose to its Western competitors the competition in the field of manned flights. But here it is necessary to express one important reservation: that competition is not the No. 1 priority among the objectives of the Soviet space program. Nor is it the No. 2 priority. Our main concerns are elsewhere—we must see to it that space research yields as high a return as possible. Above, we have examined in sufficient detail the paths that, in our opinion, will take us to that goal.

The Soviet plans in the field of manned flights satisfy that requirement: the implementation of the project for the future orbital complex has been moved to a time much later than that of the U.S. plans—to the period 2000-2005. In light of the current state of our economic system, that is, undoubtedly, a wise decision.

Summing It All Up

In turning to the summation, let us recall the words K.E. Tsiolkovskiy wrote at the very beginning of the century in his unpublished work "Ethics or the Natural Foundations of Morality":

> "A great many urgent problems cannot be solved right now, whereas life demands that they be solved, no matter what the cost. Hence, the need...to have firm, staunch views and solutions of difficult problems, so as not to be running in place, but rather to move forward, even if on a risky path."

The problem that this paper has addressed is this—to analyze the possible paths and means for increasing the space program's return to the national economy. The authors have attempted to find not so much original recommendations—for originality has little significance

for the stated problem—as they have tried to find practical recommendations. Briefly, those recommendations look like this:

- further intensify the processes of democratization and glasnost in the planning and conduct of space research
- expand substantially the information on the aerospace potential
- continue the step-by-step reduction of the military space potential of the opposing sides within the framework of the concept of adequate security
- give priority to the national economic areas of the space program
- removal the departmental barriers to the transfer of space program's technology to the national economy
- apply the scientific and production potential of the aerospace complex directly to the solution of urgent national economic problems
- improve the organizational structure of the aerospace complex, to include subdividing enterprises, switching them to leasing conditions, and creating interdepartmental and international associations
- further optimize space programs by increasing their scientific and applied return
- the USSR Supreme Soviet should confirm the State Program for the Development of the Space Program
- establish a USSR Council of Ministers' State Committee for Space Research in order to consolidate the financing of the efforts of the academies of sciences, the sector ministries, and other departments

And a final comment. In completing a work devoted to so complicated a question as the determination of the prospects for the development of the space program, the authors believe least of all that, apart from their views, there are no other proposals to be made. The only thing on which they insist is that, in our rapidly changing world, this question be discussed in the most serious fashion. The authors would like to hope that their work will help to determine the best paths for further developing our space program and for increasing its return.

Leonov Discusses Costs, Benefits of Space Program

907Q0079A Moscow KRASNAYA ZVEZDA in Russian 12 Apr 90 First Edition p 4

[Interview with Major General of Aviation Aleksey Arkhipovich Leonov, deputy chief of the Cosmonaut Training Center imeni Yu. A. Gagarin, Pilot-Cosmonaut of the USSR and Twice Hero of the Soviet Union, by KRASNAYA ZVEZDA correspondent Colonel M. Rebrov: "The Space Program Is the Call of the Times"; date and place of interview not given]

[Text] **On the eve of the Space Program Day, our correspondent [Colonel M. Rebrov] met with the deputy chief of the Cosmonaut Training Center imeni Yu.A. Gagarin, Pilot-Cosmonaut of the USSR and Twice Hero of the Soviet Union, Major General of Aviation Aleksey Arkhipovich Leonov and asked him to respond to questions from the newspaper's readers.**

[Rebrov] Aleksey Arkhipovich, over the years which have passed since Gagarin's launch, we have become so used to the reports about launches of rockets, satellites, ships and orbital and interplanetary stations. The involuntary delight from the first steps into the mysterious universe has gradually given way to a more restrained, but profoundly intelligent feeling of admiration for nature's scientific feat. But then came a period of attacks on our space programs, their creators and their participants and even on cosmonautics itself. To what extent is all this fair?

[Leonov] I would not want to find myself in the position of the defenders and deflect all the claims which have been heard lately. In such a complicated and very difficult matter as the exploitation of space, there may be and, unfortunately, there are, errors and miscalculations and not always correct decisions. Let us define the main goal: why and for what? In the program for each Soviet space experiment, there is the practical embodiment of the predominant principle, "Space in the service of man!" In the space program of our days, the interests of science and industry and the purely theoretical and the practical problems merged. It, if you will, is becoming more and more confidently part of the sectors of the country's national economy. Such a concept as space industry has even been firmly established.

[Rebrov] But today, a tough demand is being made on each sector—to be profitable and economically efficient...

[Leonov] And this is fair. Let us look at the conducted space research, at the work of the crews on the Mir orbital complex and at other programs through the prism of expenditures and return

It has been calculated that the expenditures for the sixth mission to Mir—the one being carried out now by A. Solovyev and A. Balandin—including the expenditures for ground support, amount to 80-90 million rubles. Calculations have also been made of the expected economic impact. If the program is carried out completely, we will receive 105-108 million [rubles]. What makes up this return? First of all, it is produced by the experiments conducted on board the station and the modules. The manufacturing devices in space make it possible to reach the level of experimental industrial production of unique semiconductor crystals, which are so necessary for the electronics, radio engineering and even defense sectors of the national economy

Further. A space photograph is less expensive by a factor of 5-10 than an aerial photograph of the same area. Over the time of the existence of space facilities, including

unmanned ones, the economic impact from the photographs made from orbit amounted to 1 billion 200 million rubles. Let us add to this such figures as: the economic impact from the use of space-based communications systems, meteorology systems, natural resource study systems, navigation systems and others in the past year exceeded the expenditures for them by a factor of 1.5.

At times, it is thought that all the work in space is being performed on behalf of only three organizations: the Academy of Sciences, the NPO Energiya [Energy Scientific Production Association] and the Cosmonaut Training Center. This is highly erroneous. More than 900 organizations and departments are consumers of the information obtained from space.

[Rebrov] Aleksey Arkhipovich, in letters to the editor, our readers frequently raise the question: how much does the Soyuz spaceship cost?

[Leonov] The Soyuz has a lot of modified versions. The equipment is being developed so swiftly today that, with each new ship, something new also appears in its equipment and instrumentation and the individual on-board instruments and systems are being improved. This, naturally, also affects the cost. I am hard put to name a precise figure—but this is precisely what you are interested in—therefore, I will say for comparison: it is no more expensive than a Tu-154 airliner.

[Rebrov] Something more regarding the expenditures. You talked about the economic efficiency of the currently working mission. Its period for staying in orbit ends in July-August. But there are programs which are more prolonged, longer-term. Among them are Energiya and Buran. What are the total expenditures for space?

[Leonov] The expenditures for national economic space are around 2 billion rubles, around 4 billion for military space and approximately 1.3 billion rubles for the reusable Buran space system... If I am mistaken, I assure you, it is not by much. All together, these expenditures are around 7 billion [rubles]...

[Rebrov] Could you compare our expenditures with what is spent yearly by the U.S. National Aeronautics and Space Administration?

[Leonov] In comparison with the current year, the White House is planning to increase the allocations for the needs of the U.S. space department by 2.9 billion dollars and raise them to 15.2 billion [dollars]. Also in the draft, a request is being made for 1.3 billion dollars for the implementation of a new space research program, which, in the end, will make it possible to carry out missions to the Moon and Mars.

[Rebrov] Aleksey Arkhipovich, on the eve of the holiday I would not like to talk about negative expressions such as the "Award for the Supreme Test" for the space explorers, but

[Leonov] I understand. It is difficult to grasp the idea in this criticism, but I will try to explain. In my opinion, the main trouble with this type of critics is the fact that we are not, by far, telling everything about the cosmonauts' complicated and dangerous work.

Let us recall at least the fire on the launch pad and the firing of the emergency rescue system of the ship in which V. Titov and G. Strekalov were. KRASNAYA ZVEZDA told about this, but not on the following day, rather, much later.

[Rebrov] Let us sum up our conversation. The most memorable landmarks of the traversed path...

[Leonov] Gagarin's flight. And not just the fact that, for the first time, man burst into still completely unknown and hostile space. This was a great beginning.

But there have been a lot of memorable landmarks. On the other hand, why just "have been"? I am convinced that there "will be" also. The space program of tomorrow is the subject of the research and reflections of scientists, engineers, cosmonauts, journalists and science-fiction writers, a unique synthesis of scientific and technical predictions and ideas, which are "forming" our space tomorrow from the successes of today's cosmonauts. And these successes exist, let us be objective...

You correctly noted that we have become accustomed to space flights. Time is taking its toll and they, naturally, have ceased to be a sensation. But are we not looking a little too prosaically at what is occurring? Just consider: could people 200, 100 or even 50 years ago really have imagined what events would excite the world, beginning with the second half of the 20th Century? Indeed, we have achieved what our forefathers could only dream about and create legends and myths. But now, frequently, fascinating dreams and their realization go side-by-side. The space program is the call of the time.

Cosmonaut Savinykh on Benefits From Space Program, Status of Space Budget

907Q0085 Moscow SOVETSKIY PATRIOT in Russian No 12, Mar 90 p 11

[Interview with Viktor Petrovich Savinykh, USSR Pilot-Cosmonaut, twice Hero of the Soviet Union, rector of the Moscow Geodesy, Aerial Photography and Cartography Engineers Institute, and USSR People's Deputy, by SOVETSKIY PATRIOT correspondent Galina Sedykh, under the rubric "Interview About a Problem": "Do We Need Space?"; first two paragraphs are source introduction]

[Text] **Previously, we knew only when a spacecraft took off, when it landed, and that the cosmonaut received the Hero's Star. And that was all. The people rejoiced. Today, we know that just one minute of space communications costs 40,000 rubles... The people have begun to grumble—**

they are discontented: our money is going somewhere, but what benefit are we getting from space, or are we getting any benefit at all?

We interviewed Viktor Petrovich Savinykh, USSR Pilot-Cosmonaut, twice Hero of the Soviet Union, rector of the Moscow Geodesy, Aerial Photography and Cartography Engineers Institute, and USSR People's Deputy.

[Savinykh] Recently, we, and even the space program in general, have been criticized in every way possible. But I would like to take this opportunity to express my own point of view. Take the past year, for example: the Mir station is operating, the new Kvant-2 module has been delivered to it and is transferred to the docking assembly where it is supposed to be. The other day, work was performed on undocking of the spectral and photographic equipment which was sent into orbit so that space could give something back to the Earth. One more module will soon be sent into orbit. It also was placed on a cycle of preparations for flight in 1989 and its tasking includes an extensive program, especially in materials science. On this manufacturing module are several electric furnaces, the purpose of which is to melt billets delivered from Earth and to obtain superpure crystals in the greatest quantity. After all, they are so necessary in the radio electronics industry.

[Sedykh] Viktor Petrovich, just how much does such a module cost?

[Savinykh] I don't know exactly. Roughly, with a full complement of equipment, it can be estimated to be somewhere around 500 million rubles.

[Sedykh] Is space so profitable? What does it give to the individual, the national economy and the country as a whole?

[Savinykh] If we are talking about it as we would about an enterprise, in which money is invested and which is supposed to turn out products, then it is still unprofitable, because this is not mass production. However, I want to emphasize that we should be thinking about the future.

[Sedykh] But, forgive me, Viktor Petrovich, the space era began in '57, and we have been thinking about the future for three decades now...

[Savinykh] Yes, in fact, many years have passed. And all this time, we have been moving forward. Today, we have forgotten about the fact that the entire Far East and all of Siberia are watching their first and second television programs, and there are telephone communications via space-based satellites. So, if you consider that, then there is a contribution. Furthermore, today, a map (with a scale of 1:25,000) of the entire country has been made, and that was possible thanks only to space-based photography, because you can't photograph the entire country by any other means. What's more, if a space photograph of 1 square kilometer costs from 10 to 20 kopecks, an aerial photograph costs 1 ruble 40 kopecks In the first place, the savings over a year is 1.5 million rubles, i.e., it is cheaper by a factor of seven. In the second place, we can make any maps faster.

All this is greatly needed by our people. As proof, let me say that the maps given to us by space three months before the tragedy in Armenia showed that the intense vibrations in this region had raised the ground surface several centimeters.

Today, we should look at the space program in terms of common, global development. What has it given not just to our country, but also to the entire world? It is giving more to the entire world than to us because now the entire world is actively pursuing a space program. For example, Japan is getting ready to establish a Moon base in 1990, while we are saying that money for space must be cut back...

Many of the things which we were the first to discover we did not advance, for a number of reasons. And today, everyone thinks that since there is no direct return from space (we are spending 1.5 billion rubles a year), then, we need to take away the money. They are flying, admiring the stars and spoiling the weather, but it makes no sense, the man on the street is thinking. Those maps and photographs which we made from space are still classified. Yet, at the same time, we are selling them abroad, for they are the best photographs in the world, with a resolution of 5 meters to the centimeter. The Americans are photographing at 15 meters to the centimeter, and the French, at somewhere around 10 meters.

As for continuous ecological monitoring of the planet, that can be done only from space. The satellites fly and transmit information to the ground to a specified center. But small stations need to be set up all across the country—radio beacons which react, for example, only to the discharge of gas in a city or to radioactivity. Their signal goes up to a satellite and then from the satellite down to the center. In a word, what occurred in Kamchatka would be known in Moscow 5 minutes later. With such global space communications, it would be possible to have complete monitoring.

[Sedykh] But when will that be done?

[Savinykh] The plans are being worked out, but, again, money is needed for it.

[Sedykh] Viktor Petrovich, in your opinion, what is the state of space affairs in the United States and in our country? Although we were first, they have the Shuttle. They repair their own stations and have flown to the Moon, but what about us?

[Savinykh] They have the Shuttle, and we have Buran. We developed the very same system, although somewhat later, because we didn't need it. What pushed us toward the development of Buran was the fact that the Americans had such a system. And also the ambitions of our highest leaders, especially those in the military

The Americans are thinking all the time about the same direction we pursued: the path of research using manned stations. They intend to set up the Freedom station by 1995, and it will perform the same tasks that we are now performing on the Mir station.

We have solved the problem of the duration of the flights. And not just for getting the bugs out of the control and power-supply systems, but also for finding out how long a person can work in orbit. And that is an enormous leap forward.

Today, the Americans do not have any systems other than the Shuttle. They have launched several satellites using Chinese rockets. The telescope that was made in the United States has yet to be launched. Its turn has not come. And, considering the large cargo manifest, it is significant for them.

Yes, the Americans have flown to the Moon. But here, too, there are subtle differences. We made the first satellite; ours was the first man in space, Gagarin; ours was the first spacewalk... And the list goes on. But the Americans are the kind of people who have to be first, no matter where it is. They mustered all their forces and made the usual dash. After all, back then there really was a competition between the systems. So the landing on the Moon became their national program.

Back then, S. P. Korolev was also working on spacecraft for a flight to the Moon. We had a lunar program which was working in two areas: one chief designer was making the rocket and the craft for circumlunar flight, while the other, Korolev, was making the vehicle for landing on the Moon. But Sergey Pavlovich, an obvious leader, died, and they shut down the program, although several Zond-type craft did fly around the Moon and land on it, before the Americans. Moreover, a shuttle-type project was ready in the sixties. So the idea is not new. But, again, they shut down the program. They considered it unnecessary.

[Sedykh] Does that mean that we are, all the same, ahead of the United States?

[Savinykh] We are not engaged in a competition—it is simply that, in many aspects, we are having greater success. I want to add that our Buran has an automatic landing system, while the Americans are saying that it will be several years before they can land their own shuttle with automatic equipment.

[Sedykh] Viktor Petrovich, there were discussions in the Congress about reducing the allocations for space. Why do you think such a proposal was made? Who will gain from it, and is it really necessary?

[Savinykh] During all the years of the space era, the topic of space was closed to the public, and there was no information of any kind, and that, I believe, is why the idea about reducing financing even emerged. The people weren't aware of what we were doing, how difficult the cosmonauts' work was, how complicated the path to the stars was and what the price tag was for the developing of outer space. Here's something for comparison. The Ministry of Land Reclamation and Water Resources is annually sinking 18 billion rubles in the ground, conducting land reclamation where it is more advantageous to them and not to the country. The Aral Sea disappeared "thanks" to the Ministry of Land Reclamation and Water Resources. And that's certainly no secret. But 1.5 billion rubles are being spent on space. They say that doesn't matter—it's a lot. And this year, what is most interesting is the fact that everyone's funds have been cut, but land reclamation has again been given 10 billion rubles. Space will get, at best, 1 billion rubles for all development.

Now our space industry is seeking orders and money. But not one capitalist country in the world has put its space program on a cost-accounting basis—they are all subsidized by the state. Global scientific research, I am convinced, should not be put on a cost-recovery basis.

All the sectors of the space program are quaking in their boots today—will they shut us down or not. The same goes for Buran... But, indeed, this is a national question! And the state should decide. Judge for yourself who will gain from the cutting off of funding for the space programs. Today, the rates of development for science and technology are such that a year's delay is equal to a lag of 10 years.

And there's more. If the food program has been resolved three years ago, space wouldn't be an issue today. We would be working as before, and the people would support us, because they would all understand that it is necessary. But, of course, when a person is hungry, he is not interested in Mars. After all, crystals from space don't end up on the consumer's table. The Americans are recovering their own space expenditures by seeing to it that all the output goes for the needs of society. For example, the flight to the Moon gave an enormous push to the development of U.S. computer technology.

The entire world is proceeding along the path of systematic development of space technology and development of the Earth with spacecraft. Are we really going to be faced agains with what happened in the sixties, when programs were shut down and then we were accused of lagging behind?

Problems of Space Program Financing, Launch Plans for 1990

907Q0082 Moscow PRAVITELSTVENNYY VESTNIK in Russian No 15, Apr 90 (Signed to press 6 Apr 90) p 12

[Article by G. Lomanov: "Flights in Our Dreams and Flights While We're Awake: What's the Purpose of Our Attempts to Go Beyond the Planet's Boundaries? It Is Appropriate To Raise This Far-From-Idle Question on the Eve of the Space Program Day"]

[Text] Judging by the articles in certain central newspapers, there is no issue more important in the space program today than the flight of a journalist to the Mir station. The hullabaloo began after USSR Glavkosmos signed a contract with a Japanese broadcasting company. The routine commercial deal greatly injured the self-esteem of many representatives of our press. That is very understandable—each wants to grab on to the Wheel of Fortune, although, of course, no one has said that outright. On the contrary, they have been appealing to the noblest feelings and, above all, to the readers' patriotism—the first journalist in orbit should be a Soviet journalist, not a Japanese journalist. A hail of reproaches has been rained down on USSR Glavkosmos: it is, they say, like the Biblical Esau, selling its first-born for a mess of pottage.

All that talk smells strongly of the years of stagnation, when we haughtily proclaimed that the Soviet meter is the longest meter in the world. But, if I may point out, if it's really so necessary, for the sake of prestige, to again be "ahead of the entire planet," what the heck are you colleagues of mine getting so worked up about? Everything's OK—a Soviet journalist has already been in space. In 1975, a member of our creative union, USSR Pilot-Cosmonaut V. Sevastyanov, worked for 63 days together with P. Klimuk aboard the Salyut-4 station. But those who want to make the very first tracks in the snow on the space path are stubbornly silent on that fact, apparently implying that Vitaliy Ivanovich's membership in the USSR Union of Journalists is simply a matter of form. I dare say it's not. He has been directing the show "Man, the Earth and the Universe" for many years, and there hasn't been any drop-off of interest in it. He has a stack of published booklets and newspaper and magazine articles, and his shows and scripts have repeatedly won honors and prizes. But then in the end, neither an official position nor a diploma do a journalist make.

In a word, no one is selling their first-born. And it's not a mess of pottage which USSR Glavkosmos will receive for this deal, but rather, the impressive sum of $12 million. The payments are already coming in, and the Japanese and Austrians have transferred more than two million rubles' worth of hard currency to us. The USSR Ministry of General Machine Building spent half of this money on the purchase of equipment for the production of needles for disposable syringes. Why don't we let the reader judge which is more important—the struggle against AIDS, or someone's incessant ambitions? Incidentally, since the topic has come around to hard currency, it won't hurt to recall how one former minister, in a polemical and patriotic fervor, even promised to earmark that currency for the flight of a Soviet correspondent. He promised it to spite stingy Glavkosmos, "having forgotten" that the hard currency was earned not by him personally, but by the sector. I will not name names, especially since that minister is now in the forefront of the struggle for technical progress and, I hope, is evaluating the genuine and the imaginary priorities more sensibly.

Go to any library, walk through the stacks, leaf through the newspaper file, and you'll see that mounds of books and thousands of articles and reports have been published about the space program. Everything has been written and re-written, yet the collections, which have made the authors and compilers happy, have not become best sellers and are quietly gathering dust on the shelves. What will one more reporter add to that? Will he tell us that our planet is round or show us how a pencil and a notebook float in weightlessness? The cosmonauts are handling that in the televised sessions.

I understand the Japanese—a broadcasting company needs advertising, and it will pay for it. But what is happening with us? One of M. Gorkiy's heroes said: "We will solve these space questions after we have solved the social ones. And it won't be just a few who will solve them—it will be millions of minds freed from the concern about where their next crust of bread will come from!" The founder of Socialist Realism erred—I mean, it turns out that we have begun solving the space problems before the social ones. Does that mean it's acceptable now to gratify one's ambition, knowing as we do how invalids and pensioners live, not to mention ordinary engineers burdened with families? Let's think about the "crust of bread," the disposable syringes, equipment for the food industry, and consumer goods, whose manufacture, by the way, is assigned to the Ministry of General Machine Building. Let's criticize Glavkosomos not for the fact that it makes deals in flights and launches, but rather for the fact that it has still not expanded the commercial activities as it should.

But no, the hullabaloo is not subsiding, the "flight game" is continuing, and the pressure on the space agency is intensifying. Reflecting on the situation, A. Leonov, the deputy chief of the Cosmonaut Training Center, wrote: "The cost of cargo (the results of the research that is conducted on the orbital station), which, according to the plan, is supposed to be delivered to Earth on the return trip, is rated by specialists as being worth several tens of millions of rubles. Even with all our current mismanagement, exchanging it for "live cargo" can hardly be considered economically advisable."

Striving, in all probability, to "save face," V. S. Gubarev, chairman of the Space Commission, has already raised the question of guilty parties in one recent article: "USSR Minister of General Machine Building Shishkin, Deputy Chairman of the USSR Council of Ministers Belousov, and, finally, the General Secretary of the CPSU Central Committee—these are the people you (those who have spoiled the flight of the Soviet journalist.—G. L.) are now placing in a awkward position.

"It appears that we don't have to look very far for the 'culprits.' It is the Space Commission itself, which, in attempting to 'live' on the credit issued by the head of our state, placed itself in opposition to those who head up our space industry and space program." Such is the opinion of a person who has devoted his entire life to space. And what do they think about that in the sector?

A. Dunayev, the head of USSR Glavkosmos, told me: "Personally, I am convinced that spacecraft are launched into orbit not for the sake of someone's ambitions, but rather for the sake of scientific research and experiments needed for the national economy. That is why it is preferable to send a specialist to the station. A journalist isn't going to discover America from orbit, but his reports—let's be frank—will cost the country a pretty penny."

And so that's it, perhaps, about a flight which some people dream about in their sleep. But let's talk a little about flights that take place while we're awake—here there are plenty of problems which are by no means far-fetched. And here USSR Glavkosmos has also not been offended by the criticism in the press—opinions are being expressed that there is no common concept on how space is to be developed and that each "company" is pursuing only its own goals. The critics obviously do not know, or pretend they do not know, that management and coordination of the work at the state level between all the ministries and departments involved in space activities are handled by the USSR Council of Ministers' State Commission for Military-Industrial Affairs. The commission is guided by the approved five-year plan program, which ends this year. The program for the next five-year plan and the future guidelines for the period up to the year 2005 have more than once been discussed at the scientific and technical councils of all the interested ministries and departments—now they are being considered in, as it has become fashionable to say, a second reading. They call for the development of both basic research in astrophysics, solar-terrestrial relationships and planetary studies and for a whole set of national economy objectives in the fields of ecology, the study of the natural resources, navigation and communications. But when the space research program for the period up to the year 2005 and for the next five years was discussed in the ministry's board, it turned out that 41 billion rubles are needed for the long run, while 10.7 billion are needed for the five-year plan. Understandably, our greatly overburdened budget will not withstand such expenditures. The expenditures for the five-year plan had to be cut to five billion rubles. This year, around 220 million rubles have been allocated for the financing of manned flights. Is that a lot, or a little? Judge for yourself—last year, 300 million rubles were allocated.

"Our sector is in a strained financial situation," says A. Dunayev. "That's why we keep struggling to achieve economic efficiency in the space program. This year, in order to support the work of three missions on Mir and to launch to the station five 'cargo ships' and the Kristall manufacturing module, we need to find another 60-80 million rubles through commercial ventures. Nor has much money been allocated for unmanned vehicles—approximately 300 million rubles. In order to support the program, we have already been forced to dip into our own development fund.

"USSR Glavkosmos has a launch manifest for this year—I'll give you a brief idea of what those launches are. You already know about the manned flights, and I will add that the launch of the Japanese crew, at the request of the broadcasting company, has been postponed to 2 December. Now, regarding the unmanned vehicles. If everything goes well, the Kristall manufacturing module will go up to the station in April. An important event will be the launch of Almaz—for many years, this name figured only in official documents. The vehicle was developed by V. Chelomey's design group, and few people knew that that machine operated successfully in orbit under the pseudonym Kosmos-1870. The equipment aboard Almaz for rf sensing of the Earth makes it possible to produce images despite the cloud cover. Foreign partners are already displaying interest in such information.

"Over the span of a year, five Resurs-type satellites will be placed into orbit, all on an order from the USSR Council of Ministers' Main Administration for Geodesy and Cartography. Our newspapers reported that experts in the United States, after receiving the first 'pictures,' had some doubts—perhaps they were taken from an aircraft and not from space? After all, the resolution is 5 meters! There is always demand abroad for the photographs made by the Resurs satellites.

"Other satellites will also be launched: Okean O-1, which will monitor the state of the ice fields; a Foton; an Ekran-M television relay satellite; and, possibly, a Meteor weather satellite. Its launch is still questionable: there are such craft in orbit—it is simply that two of them have exhausted their useful life, but are still operating. So the launch will depend on their condition. Incidentally, any deviations from the launch plan are reported by the government agencies, and only with their permission are adjustments made. And, finally, there is the unlucky Gamma-Ray Observatory, which has been in preparation already for about eight years. At first, the sector delayed it. Now the vehicle is ready, but there are grievances against the manufacturers of the scientific equipment—the USSR Academy of Sciences' Space Research Institute and the program's French participants. All the same, we hope that the launch will take place in June.

"As you see, there is a clear-cut program, even though we are criticized for the lack of one," says Dunayev. "In particular, K. Frolov, the vice president of the USSR Academy of Sciences, has written about that. I think the reproach is off target—industry should not and cannot determine the directions and priorities of scientific research. We are ready to accept an order from any organization which is prepared to finance it—we are working successfully, for example, with the USSR Council of Ministers' Main Administration for Geodesy and Cartography and USSR State Committee for Hydrometeorology. If only our relations with academy institutions would shape up just as clearly.... Alas. Here's an example: we have the Spektr general-purpose craft. What kind of equipment should be installed on it—equipment that operates in the x-ray range, the radio-frequency range, or the ultraviolet range? Each of the

programs will cost approximately 300 million rubles, and we can't handle all three. But the USSR Academy of Sciences still can't decide which one should be given perference. We'd prefer not to merely satisfy the interests of one or another group of academicians or scientific schools, but rather to work for the needs of the USSR Academy of Sciences as a whole.

"And last of all," days Aleksandr Ivanovich in conclusion, "the space programs have always been put together after their discussion by all interested organizations. It is true that the discussions used to be closed, the public did not know about them, and, at best, the readers received fragmentary information. Two months ago, by a government decree, a number of departments, including the Ministry of General Machine Building and USSR Glavkosmos, were instructed to widely publicize everything which is being done in the space program. I would like to believe that glasnost and openness will make it possible to draw the public's attention to the really important, urgent and, at times, painful problems of the current stage of development of the space program."

Space Programs in 'Program 2005' Advocated

907Q0087 Kiev POD ZNAMENEM LENINIZMA in Russian No 5, Mar 90 pp 77-81

[Article by I. Yudin, member of the USSR Federation of Cosmonautics, under the rubric "Panorama": "The Space Program: A Peek at Tomorrow"]

[Text] *"With the current state of the economy, spending for space must be cut as much as possible. It's a real luxury—to spend such money."*

"I have never thought of the space program as a luxury! It will be an intolerable luxury if we let it fall into decay."

Yes, in current disputes, such mutually exclusive opinions are not a rarity. In order to find out who is right and who is not, it is necessary to know what today's space program is and what it means for a civilized state.

It is no secret that the aviation industry, rocket building and space-based production are high points today of scientific and technical progress. And it is not just the fact that they are producing today's most advanced products. Beneath the tip of this iceberg are the latest design approaches, the most advanced technology, and the latest materials. This "incidental" output is flowing into many other production lines, sometimes in trickles and sometimes in rivers.

Here is an example. The critics of our new, really expensive Energiya-Buran transport system somehow forget that the latest designs, technologies and materials derived during its development are made widely available to all sectors of industry. There have been no fewer than 581 such products. They consist of instruments, mechanisms, assemblies, bearings, coatings, lacquers and paints whose performance holds up in the severest conditions. Their use on the ground can increase the useful life of any piece of equipment by 2- and 3-digit factors.

The economic impact from the introduction of these proposals may reach many hundreds of millions of rubles. The designers estimate that by the year 2005 all the 14 billion rubles spent on the development of the Energiya-Buran system will be returned to the treasury.

In a short period of time, the space program has penetrated all spheres of society's life—economics, science and culture. Space has become such a permanent part of our lives that we no longer notice that we are making use of its services everyday. And those who are demanding that the spending for space be cut back are obviously not thinking about the fact that such cut-backs would make it necessary to increase spending for the development of research in the fields of communications, geology, construction, fishing... The number of consumers of space information in our country alone is approaching a thousand. The economic impact which they derive from it is estimated to be many hundreds of millions of rubles a year. Thanks to that, many areas of the space program are completely paying for themselves (and that includes the manned missions).

The national economy of a country as enormous as ours cannot get by without space-based communications and television, meteorological information, and Earth resources study, not to mention space-based navigation.

One cannot even imagine the development of science without the broad front of applied and basic research and experiments begun in space.

Nevertheless, it is only in our country, the forerunner of cosmonautics, that it has become necessary to prove that the space program is needed and that the spending for it should be kept at least at the current level. Even in the developing countries, such a dilemma does not exist. The developed capitalist countries spare no expense for space research, even though there, as we love to repeat, they know how to count their money.

No one disputes the fact that perestroyka is needed in the space program, too. The crises which engulfed the country during the years of stagnation also had a telling effect in that sphere. The actual needs of the national economy and science were sacrificed to ambitious and prestige aims.

Nor have we avoided large miscalculations. The enormous amounts of money invested in the space program's development have not always produced the appropriate return. To a great extent, we lag behind in space matters, especially in electronics, computer engineering, sensor technology and instrument building. Science and the entire national economy are suffering from this. For that reason, our spacecraft are inferior to foreign spacecraft in terms of the length of active life. The American communications satellites, for example, operate times longer than ours. That is precisely wh

our latest scientific program, Fobos, the purpose of which was to study the Martian satellite, was never consummated.

But the necessary conclusions have been drawn. The space program has been brought into conformity with the country's current capacities and needs, all the units of space production are held more responsible for the spending of the monies that are allocated to them, and only those projects which can produce the greatest impact have been accepted for realization.

The early part of this year saw the publication of the program for the development of space equipment to be used for science and national economy aims between now and the year 2005. It calls for step-by-step development of vehicles to be used for various purposes, a gradual decrease in and elimination of the lag in the technical level of domestic space equipment behind the best foreign counterparts, fuller satisfaction of the needs of science and the national economy, and the start-up of preliminary work for future realization of large-scale space projects, as well as the expansion of international cooperation and the commercial use of space equipment.

One of the most important tasks of this program is the development of highly efficient satellites for all the existing areas of the use of space equipment in the interests of the national economy. A special place among them is held by the study of the Earth's natural resources. The information obtained in that area is facilitating a more rapid development of productive forces and is making it possible to set up effective monitoring of the state of the environment, which has become extremely important in recent years. The information is used in cartography, geology, agriculture, forestry, water resources management, fishing, oceanography, land reclamation, and municipal construction. Such information is vitally important to the entire world community and is of great commercial value.

Currently in operation in the USSR is the space-based Resurs System, which is made up of three types of satellites: the Resurs and Okean satellites for day-to-day collection of information about the state of land areas, the ocean, and the environment, and the Resurs-F for photographing the Earth's surface with a high spatial resolution. In most of the photographs, the resolution is 15-30 meters, whereas for special types of photographs, it is a few meters.

The measures outlined by Program 2005 in this field will make it possible in the coming decade to reach the level of the best foreign models of space equipment and to begin broad commercial use of such information.

In order to satisfy the increasing demands for photographic information, the designers are planning to install on the satellites fundamentally new equipment for multizone photography. All the channels of such equipment operate synchronously. They record a variety of characteristics of the Earth's surface and its soil and vegetation cover, conditions in reservoirs, sea and ocean currents, and the anthropogenic impact on the environment. At the same time, for reference, a photograph is made of the celestial sky.

The Meteor-2 satellites are currently engaged in the collection of global meteorological information. Launches have also begun of the third-generation weather satellites, the Meteor-3 series, which have equipment that is more advanced. From an altitude of 1,250 kilometers, they can survey the entire surface of the Earth. In the interests of hydrometeorology, it is being proposed that there be a step-by-step expansion of the composition of the onboard equipment and an improvement of the equipment parameters.

Also being planned is the launch of a geostationary weather satellite with television equipment for producing images in the visible and infrared bands of the spectrum. It will collect data on the distribution of the cloud cover in the equatorial and temperate latitudes on the illuminated and dark sides of the Earth, as well as data on wind velocity and direction on two or three levels. The technical specifications of this system will ensure its compatibility with the international system of geostationary satellites, which are being operated by the countries of Western Europe, the United States, and Japan.

A new satellite-based television system will be created in the near future—the STV-12, which will operate in the international frequency band. It will be serviced by multichannel geostationary satellites which relay programs from the central and republic television centers. They are received by ground equipment with parabolic antennas 1.5-2.5 meters in diameter.

Plans are being made for the development of a new, more improved communications satellite. It will replace the current Gorizont satellites. It is expected to have a higher traffic capacity as a result of a greater number of broadband channels, a wider total bandwidth for the repeater, and the use of onboard and transceiving antennas that are more directional and polarized channel multiplexing.

Space is an enormous natural laboratory. Its unique conditions enable all kinds of research and experiments. Their importance is so great that, without them, the further development of modern science would not be conceivable. If applied research is limited for the time being by the framework of space technology, basic research truly knows no limits.

Space technology is understood at this time to mean experimental research for the purpose of space-based manufacturing of various types of organic and inorganic materials and substances that have characteristics that are better than those of materials and substances produced on Earth. Until now, such research has been conducted on the high-altitude Vertikal rockets, the Foton satellites and the manned Salyut and Mir stations.

Most of the attention has been devoted to the production of semiconductor materials, glasses, and metals and their alloys.

Many experiments have been conducted with organic substances—electrophoretic separation of mixtures of various biological materials and the production of vaccines.

A great deal of importance is being attached to the development of this area. Specialized space technology equipment will be developed. It will ensure the improvement of important characteristics of space-based production such as a low level of microgravity, the length of time it can be maintained stably, the power supply for the processes, the size and weight of production units, and the expansion of the assortment of materials produced. Such equipment will consist of automatic platforms and a self-contained module for the manned Mir station. They are expected to help effect the transition from experimental research to semi-industrial production and, later, to full industrial production.

Academician B. V. Raushenbakh once said: "Science, before sowing the seeds of tomorrow's harvest for the people, should rise to the rarefied heights above the clouds and then from there shower down a beneficial rain of the new knowledge and new capabilities of Man. As we reap one harvest today, we prepare future harvests."

That, of course, is a metaphor. But it has direct meaning for the basic research conducted in space.

Taking scientific instruments outside the Earth's atmosphere, which is a shield of sorts from many types of radiation which come from space, has caused a genuine revolution in astronomy and astrophysics. In a short period of time, the new knowledge has altered our notions of the world around us and of the entire universe.

Space research now includes the most important areas of the basic sciences. Being studied are space plasma, the physical and chemical conditions on celestial bodies, and the processes of the formation of those bodies in the solar system. All this should shed light on the Earth's past, present and future.

Program 2005 calls for the development of vehicles for conducting unique, high-priority research in those fields. The intermediate link between the current and future projects will be the international Spektr-Rentgen-Gamma [Spectrum X-Ray Gamma] Project. In addition to the USSR, seven European nations and the European Space Agency are participating in it. The project's purpose is prolonged observations of extraterrestrial sources which produce radiation in very high frequency ranges of the electromagnetic spectrum.

Research begun by the Prognoz-9 unmanned craft on the large-scale anisotropy of the background radiation will be continued. The Relikt-2 Project has been developed for this purpose.

Scientists believe that the investigation of the background radiation will make it possible to get an idea of the early stages of the universe's development. This radiation represents a witness to the processes which occurred approximately 700,000 years after the "Big Bang."

Information on this period is still quite skimpy. The only thing that is known is that the universe was filled at that time with a mixture of hot plasma and photons from the background radiation with a high degree of uniformity. But, in the original plasma, regions of increased density are though to have formed, from which the galaxy clusters, the galaxies themselves, the stars and the planets subsequently formed. That is why the search for fluctuations (deviations) in the temperature of the background radiation has at present become a fundamental experiment. Those fluctuations contain direct information on the development of the universe—beginning with the earliest superdense stage and ending with the present stage—and on the moment of formation of gravitationally linked objects and their properties.

In order to preclude the influence of interference caused by the thermal radio emissions of the Sun, the Earth and the Moon, the spacecraft for such research must be 1.5 million kilometers from the Earth in opposition to the Sun.

Yet another important area of basic science is the investigation of solar flares. Scientists have been studying them for nearly a quarter of a century. Over that period of time, our knowledge of the complicated system of phenomena associated with the flares has increased immeasurably. Nevertheless, there is still not enough data to develop a complete theory. We would like to define more precisely where the solar plasma particle accelerator is located—in the corona or in the chromosphere—which of its characteristics are the precur[illegible] the flares in the various bands of the spectrum, a[illegible] the mechanism is for the release of the energy.

A[illegible] an explanation of the influence of solar a[illegible]n near Earth space remains an important goal, sin[illegible] much of what occurs on the Earth is caused in one way or other by the influence of the Sun. That is why the satellite's onboard equipment will engage in a diagnosis of the state of the near Earth plasma while it is observing the phenomena on the Sun.

The Koronas Project also calls for one of the first experiments on helioseismology—the observation of the fundamental components of the Sun's vibrations.

Program 2005 is giving a prominent place to the development of manned flights. Basic research in the fields of astronomy, astrophysics, biology, medicine, and manufacturing and the study of the Earth's natural resources

are expected to continue on the Mir station. What will be new in the cosmonauts' activities is the maintenance of automatic facilities intended for various purposes, which will have been developed on the basis of large-scale structures.

One project being proposed involves a future, permanently operating orbital complex that is considerably larger than the Mir station in size and crew. Its basic component is a base unit with a large number of docking assemblies that will enable various modules and cargo and transport craft to link up with it. It will have a rather heavy-duty power supply unit (up to 100 kW), devices for independent movement by cosmonauts in open space, manipulators for assembling and servicing large-scale facilities, and unmanned and manned "space-to-space" towcraft for transporting those facilities to their working orbits.

It is being proposed that the new orbital complex include astrophysical facilities with unique instruments—telescopes and interferometers on special steerable platforms.

As an alternative to SDI, the notorious American "Star Wars" program, M. S. Gorbachev has proposed to the United States and the rest of the world community that a joint mission to Mars be organized. The target date is 2015-2017. In place of the wasteful space arms race fraught with unpredictable consequences, our country is proposing that the preparations for such a mission begin little by little. Thus, the consolidated scientific and technical potential of the many countries would serve not the god of war, but goals of creation and scientific-technical and social progress. It is easy to understand how the cause of peace and cooperation among peoples would gain from this. The wisdom of the proposal has been understood and rated highly by the world community.

But why Mars specifically?

That planet represents the most interesting target for a visit by man. Unmanned spacecraft have already been on it. We know a lot about Mars, but, as before, it attracts our gaze and stirs the imagination. The fact is, obviously, that it bears a great resemblance to our Earth.

The surface and climate of Mars are exceptionally interesting. There are data that indicate that, in the past, the atmosphere there was denser, the climate was warm, and rivers flowed on the surface. It has not been ruled out that life exists or did exist on the planet, at least in the simplest forms.

The Mars researchers are faced with a set of high-priority scientific problems. The landing a person on another planet could in itself become an event of epochal significance, a unique symbol of humanity freed from wars and the threat of ecological catastrophe.

The USSR and the United States already have considerable experience in long-duration spaceflight. Those countries have developed powerful reusable transport systems and launch vehicles and have mastered the in-orbit assembly of complicated large-scale complexes. The combined scientific and technical potential of the USSR, the United States, and the countries of the European Space Agency, makes it possible, from the technical standpoint, to talk about a mission to Mars as a matter which is quite feasible.

But the Mars mission, by its very scale, far exceeds anything that has ever been done in a space program. According to the American estimate, the spending levels on it could reach $100 billion. We believe that those levels could be kept to $50-70 billion. Those are colossal amounts of money. No single country is in a position at the present time to handle such spending. That means that the discussion can center only on international cooperation and on the consolidation of all of the Earth's space potential for the sake of this noble goal. But that will depend on the trends in the development of the larger political picture, on the success or failure of the disarmament talks and, finally, on how our perestroyka turns out.

Our plans call for a large amount of research on Mars to be done by unmanned craft. That research can be viewed somewhat as reconnaissance, as preparation for the mission, and as an independent program for solving scientific problems on a new and higher technical level. It involves three stages, from 1991 through 2015, and will require the development of various pieces of space equipment.

Among the problems to be tackled are a detailed photographic survey of the entire surface of Mars, an investigation of the mechanical and chemical composition of the soil (both on Mars and after it has been brought back to Earth), magnetic and gravitational surveys, long-term observations of the planet's climate, and a careful selection of the landing site for the future mission. All those problems have a high scientific priority.

The research should use small and large Martian rovers with a long service life, balloon probes for drifting in the atmosphere, and penetrators which can be hurled to the surface to obtain meteorological information from various regions of the planet.

That is a general outline of the strategy which our scientists and designers have submitted to the tribunal of the public for the further development of space.

Despite the difficulties the country is experiencing, I would like to believe that the people who kindled space era of man will confidently continue the climb up the ladder of space.

Semenov Discusses Benefits From Mir Program, Shuttle Versus ELVs, Conversion

907Q0091 Kiev PRAVDA UKRAINY in Russian 12 Apr 90 p 4

[Interview with Yuriy Pavlovich Semenov, general designer of the Scientific Production Association Energiya, Hero of Socialist Labor and recipient of the Lenin and State prizes, by PRAVDA UKRAINY correspondents N. Mikhaylov and G. Nikolayenko, under the rubric "Today Is the Space Program Day": "Who Needs Space?: Yu. P. Semenov, General Designer of the Scientific Production Association Energiya, Responds to This and Other Questions for This Newspaper"; first two paragraphs are source introduction]

[Text] **When the Earth's first artificial satellite was launched in October of 1957 from a Soviet cosmodrome, Yuriy Semenov was doing his practical work for his degree in Dnepropetrovsk, in M. K. Yangel's design bureau. When the first man went into space in April of 1961, Yu. P. Semenov was a young specialist at that design bureau. Over the three decades that have passed since that time, the space program has moved far ahead and has become an enormous, independent sphere of human vital activities. A lot has also changed over that time in Yuriy Pavlovich Semenov's biography. He was the leading designer of the Soyuz craft and chief designer of the Salyut and Mir manned stations and the reusable Buran ship. Today, Yu. P. Semenov is a general designer. He heads up the collective whose creator and first manager was S. P. Korolev. No, there is probably no need to mention how very difficult that post is. Especially at the present time, when the execution of the increasingly complicated space research program is accompanied by critical barbs aimed at the program and there are sharp debates about how space is costing the country a pretty penny and, in the current situation, is hardly useful or necessary to the country. And the zealots in the debates are not just people who are far removed from the space program, but also scientists, some of whom are from the fairly well-known Space Research Institute.**

So what is the exploitation of stellar space giving us? Our correspondents' interview with Yuriy Pavlovich Semenov, the prominent Soviet designer of space equipment, Hero of Socialist Labor and recipient of the Lenin and State prizes, began with this question.

[Semenov] Only a person who is uninformed or biased could take exception to the fact that the space program today has become one of the moving forces behind scientific and technical progress. Advanced space technology and equipment are being widely introduced into various sectors of the national economy. The space program is one of the few sectors of technology in which our country is one of the world's leaders. That is an indisputable fact and a convincing achievement of our country, and it represents our country's most important potential.

And look at the curious turn which the world's advanced countries have taken in their own space programs. They have, following our example, sharply envigorated their work in the development of orbital stations. In the United States, a new-generation modular station is being developed. The countries of Western Europe, Japan and Canada have joined in its development. At the same time, the European Space Agency and Japan are also planning to develop their own orbital stations in the future.

The endeavor to conquer the "space market of the future" is no accident, for that is viewed as a routine step in raising the scientific, technical and economic potential of any country, no matter how developed it is today. Even Japan, whose achievements are known to everyone, is currently setting a goal of developing operations in space as one of its fundamental national goals.

Having achieved a definite preeminence in the field of manned flights, which are playing a decisive role today in the "space market," we should not, under any circumstances, rest on our laurels; if we do, the preeminent scientific and technical work we have started will be used by other countries tomorrow. From a state which offers the foreign market the most science-intensive products we will become a country which purchases medicines, electronic equipment and many other goods whose parent components will be produced in space.

We must not scrimp on the space program. That could cost the state, society and our descendants dearly, and the space program would risk slowing down, and one of the country's most advanced and well-organized sectors could lose its importance.

As for the resounding criticism directed at the space program, this must be said: Anything can be criticized. That has become particularly fashionable nowadays. Of course, differing points of view may exist for any set of problems, including those of space. But criticism should not be just for the sake of criticism. It is very important to delve into the causes underlying such criticism. And if legitimate causes really do exist, they must be eliminated.

That is why, when we are criticized by those who have nothing to do with the space program and who allude to the opinions of people who are not very competent and whose main argument is the size of the expenditures, which are reaching many, many billions of rubles, we view that criticism as a consequence of the secretiveness and inaccessibility of space projects for broad discussion in the not so distant past. Much has been done to surmount the barrier of secrecy, although not everything that needs to be done. But even what has been called in the press the true budget for the entire space program— and it is one order less than the what is spent for the Ministry of Land Reclamation and Water Resources— gave many critics an opportunity to [illegible]

what the impact from the proposed reductions in the "space budget" and what the consequences of that move would be.

There is another source of criticism—it is a delayed reaction to the "free" flights given to cosmonauts from friendly countries. Well, that's a cost associated with our foreign economic policy with these countries from past years. Even here, some conclusions have been drawn for the future. Although, in analyzing the numerous launches of international crews, we shouldn't disregard the fact that they made it possible to master to perfection the procedures associated with visiting crews, procedures we are now successfully using in the commercial proposals for flights by cosmonauts from Japan, Great Britain, Austria, the Federal Republic of Germany and other countries. Nor should we fail to take into consideration the unique equipment developed by the socialist countries and used on the Mir complex.

Obviously, some of the criticism has also been caused by the paradoxical statement of the question—man or machine? All the experience of the space program shows that only a human researcher in space, together with machines which free him from routine work, can solve problems effectively.

With respect to the critical speeches made by representatives of the academy institutes, the most probable reason for those speeches were the changes in the economic relations between the institutes and the space sector. What is the problem here? Various types of scientific research equipment for studying the Earth and space were developed by the institutes of the USSR Academy of Sciences and the academies of the union republics via agreements in which the space sector's enterprises and organizations were the customers. Those agreements enabled the institutes to use the additional monies for their own development and for raising the incomes of their own associates. The space program thereby exerted a direct influence on the acceleration of the development of advanced science in various spheres of knowledge.

Today, the representatives of the academy institutes are proposing to change that mechanism for mutual relations in such a way that they would become the customers for space vehicles on which the instruments they develop are installed. We are prepared, based on the experience of international commercial activities, to support those proposals, but with the stipulation that the entire system for supporting space flights be included in what they order: the launch devices, the transportation systems and the use of the space complexes and the tracking, control and data processing facilities. At the same time, the existing way of doing things doesn't have to be done away with right away, even if it's a consequence of the administrative-command management methods. The history of our country knows examples of destroying a system without the proper prediction of its results.

[Correspondent] In heading up the NPO Energiya, you are, in essence, the Chief Designer for "habitable space." As we all know, that term has a broad connotation that includes not only where the cosmonauts stay and work (the space stations and modules), but also the equipment used for placing them into orbit (the launch vehicles and spacecraft, to include the reusable ones). What do you see as the near future for this area of the space program? What do you expect in the more remote future?

[Semenov] The comment about the broad connotation of the concept of "habitable space" is profoundly correct. All of our activities are aimed, in the final tally, at making space truly habitable, so that man may derive the maximum benefit from the unique properties of the space which surrounds us. Even now, our insights into the habitability of near-Earth space are comparable to those of the habitability of ground polar stations. The experience we have gained has already enable us to convert the program of operations on the Mir orbital complex from a mainly scientific-technical orientation to a scientific-production orientation.

It should be noted that the space programs abroad are financed by the state. And perhaps only in our country, thanks to the enormous amount of experience we've gained in the operation of orbital stations, does the theoretical possibility exist for space research to pay its own way. Today, the annual needs of the Ministry of the Electronics Industry, the Ministry of the Electrical Equipment Industry and the Ministry of Defense for materials produced in space are estimated in tons, which promises an economic impact of many hundreds of millions of rubles a year.

The biotechnology experiments conducted in orbit to produce valuable medicines and diagnostic preparations have shown that the productivity of the process for electrophoretic separation of proteins with a high degree of purity exceeds that of the ground-based process by a factor of 1,000. This is a very important result. Test batches of genetically-engineered interferon have been cleansed of impurities and its biologically negative forms, a process that presents problems when undertaken on the ground. The probable economic impact from that area of man's space activities is also estimated in hundreds of millions of rubles a year.

All this testifies to the fact that the future lies in space-based production. Satisfying the needs of our national economy and medicine requires new-generation complexes which weigh hundreds of tons and have a power supply of up to 500 kW. The experience gained in the use of the Mir station and the Energiya-Buran system which has been developed are opening up opportunities for the achieving that goal. Today, we have no problems delivering the necessary materials (cargoes) into orbit and returning them to the ground.

The equipment developed and proven at the beginning of this year for moving a cosmonaut around in open space makes it possible to assemble the large structures which

are needed to increase the power supply for orbital complexes. And, it must be said, we are very near to solving these matters.

Another important area of the work done on the orbital stations is the organization of global ecological monitoring of the planet. I don't believe it's necessary to convince anyone of the importance of that area.

In other words, the possibilities for the orbital stations are practically inexhaustible. There is no doubt that man's "celestial apartments" will undergo improvements and that there will be plenty of work done in them in the next decade as well.

I would add to what has been said that the manned space program is not limited to the exploitation of near-Earth orbits. We are currently conducting studies on the development of an interplanetary manned complex for a mission to Mars. Undoubtedly, such a project is of importance to all of humanity and will be executed in the context of worldwide international cooperation. I believe that the execution of that project is a matter for the not-too-distant future.

[Correspondent] As is evident from your words, man is achieving ever greater mastery of near-Earth space. The space-based systems for communications, navigation, weather and Earth-resources study are, as before, based on orbital vehicles and are of the greatest practical benefit today. Expendable launch vehicles place them into orbit. Will the situation change if Buran begins to make regular trips into space? Or will a certain division of labor be maintained? What, in your opinion, would be the best combination of work in space for Buran and the expendable launch vehicles?

[Semenov] The orbital delivery systems are continually being improved. Both the reusable complexes and the expendable launch vehicles have their own special features and spheres of application. The expendable launch vehicles are quite inexpensive, but they do have a number of shortcomings. The reusable Buran ship, which is a large-cargo transport craft and which possesses properties unattainable for the usual expendable orbital-insertion equipment, has the capability of returning from orbit expensive facilities which have exhausted their own useful lives or have experienced unforeseen failures.

And yet, the return problem should be viewed as being on the way to being solved, whereas the main problem involves the launching of expensive craft equipped with unique scientific instruments—for example, a large optical telescope with complicated electronic equipment. Such craft must be carefully checked out after they're placed in orbit before they can be left there to handle a given problem. Other examples are projects which require the in-orbit construction of large radio telescopes, antenna systems, orbiting solar electric power plants and interplanetary complexes, are expensive one-of-a-kind structures that require servicing by skilled specialists (manipulator arms and robots). Naturally, it would make sense to put all that into orbit in a single trip. But for all its great capabilities, today's reusable Buran craft has a substantial shortcoming: the cost of launching it is quite high.

That is why Buran cannot compete with the traditional launch vehicles in putting things into orbit. Our plans are being built on a sensible combination of expendable and reusable launch systems.

A promising delivery system, which would replace the present-day expendable launch vehicles and reusable craft, is the aerospace plane, which would use the Earth's atmosphere both for the development of additional lift and as a rocket-fuel component. It would go aloft into space and return like a modern aircraft and would be an inexpensive means of delivering cargoes into orbit and returning them to the ground.

But the path to the realization of such projects is through the development and use of today's reusable systems such as Energiya-Buran and the entire complex of experimental bases and ground facilities which ensure the development and use of those systems.

[Correspondent] In addition to the words *perestroyka* and *glasnost*, another term has found a solid place in our lexicon—*conversion*. The field in which you work has a direct bearing on peaceful space. Information about what the cosmonauts manage to produce or do in orbit is appearing ever more frequently in the newspapers and on television. Nevertheless, what are the possibilities for the Energiya scientific-production association making a direction contribution to the country's national economy, and what specifically is being proposed so that it can do that in the near future? And what, in your opinion, should conversion consist of?

[Semenov] Conversion is a very serious problem. On the one hand, it is quite natural and necessary that a powerful sector such as the Ministry of General Machine Building—of which our organization is a part and which possesses the most immense scientific and technical potential—make its own contribution to the development of the "non-space" sectors of the national economy. On the other hand, you can't let people go around "hammering nails in with a microscope." I say that to emphasize that it is necessary that our organization and ones similar to it be involved in solving only science-intensive problems which require the use of advanced technologies. Unfortunately, in life, things frequently happen quite differently, which can ultimately lead to a big loss of our potential. We must not give our assent to something like that.

That is why, in the conversion plan we have tackled the solution of one of the vital problems of our national economy and of society as a whole—that of linking our country via communications technology. There's no need to give the specifics of the state our communications are in. Suffice it to say that in that area we are in 26th place among the world's nations. Of the [illegible]

populated centers of the Soviet Union, 107,000 do no have telephone communications.

Based on the experience we've gained in the development and operation of the Salyut and Mir orbital stations and the Energiya-Buran system and using the cooperation that has come about between the design bureaus and the plants, we began developing large space platforms (up to 18-20 tons in a geostationary orbit) for communications and radio and television broadcasting. A goal has been set to provide every type of communication via telephone channels to every remote corner of our enormous country, to solve the problems of radio broadcasting, and to ensure the transmission of multiprogram television and high-definition television. This will make it possible to have remote consultations with leading specialists in medicine, to set up rapid nationwide referendums on urgent questions, including those of internal politics, and to make the achievements of advanced culture accessible to each of the country's citizens. The installation on these platforms of a variety of equipment will make it possible not only to establish powerful communications systems, but also to implement permanent ecological monitoring in all bands of the spectrum of electromagnetic waves.

The Ministry of Geology has also turned to us with a request for help in the development of a system for deep-water mining of iron-manganese nodules in the Pacific Ocean. This is also a science-intensive task.

We have a rather vast program for conversion, which also includes the development of sealed operations rooms that have atmospheres of special composition and pressure, and many other things.

Certain conversion programs in which we are participating do not have a direct bearing, as it were, on the space program. But we have joined in on the work enthusiastically, understanding our enormous responsibility in terms of solving the country's particularly acute social problems. In that work, first and foremost is the state program for the building of prostheses, in which our enterprise is the lead enterprise. In brief time spans we must develop prostheses which are on a par with the best models produced by the leading foreign firms.

I believe that we are up to the task, although we have encountered many problems here.

So, in response to your original question about who needs space, my answer is unambiguous: it is needed by our entire state and by each of us. The development of outer space has yet to bring man "mountains of bread and endless power," as K.E. Tsiolkovskiy predicted. But, after all, the applied space program has existed for a little more than three decades. We are only at the beginning of the path to the stars. But the steps which have been taken on this path are convincing proof of the fact that this path is opening up enormous creative possibilities for man.

General Designers Describe Rivalries Among Space Design Organizations

907Q0084 Moscow SOYUZ in Russian No 15, Apr 90 p 15

[Interview with general designers Gerbert Aleksandrovich Yefremov, Scientific Production Association of Machine Building (NPO Mashinostroyeniya), and Dmitriy Alekseyevich Polukhin, Salyut Design Bureau of the Scientific Production Association of Experimental Machine Building (NPO eksperimentalnogo mashinostroyeniya), by SOYUZ correspondent Dmitriy Khrapovitskiy, under the rubric "Absolutely Unclassified": "The Ground Waves of Space Politics"; first paragraph is source introduction]

[Text] **General designers Gerbert Aleksandrovich Yefremov (Scientific Production Association of Machine Building) and Dmitriy Alekseyevich Polukhin (Salyut Design Bureau of the Scientific Production Association of Experimental Machine Building) talk about the fate of certain space projects in SOYUZ's editorial office.**

[SOYUZ] You represent space science and technology. Many people are now certain that you, the space designers, are people who are satisfying your own curiosity at the expense of the rest of the country's citizens. I'll put the question differently: looking at our space age, tell me, might it turn out to be not so "golden"?

[Yefremov] It might not. But that answer, of course, needs some supporting proof. Do you agree, Dmitriy Alekseyevich?

[Polukhin] Well, let's try to explain the billions which have been spent. The esteemed K. P. Feoktistov, for example, is certain that it is all a matter of the lack of a strategic policy for the development of space. But come on (and don't consider my statement a populist defense of my own work), can we find in our recent history even one strategic development policy—any kind!—where there's a noteworthy result?

[Yefremov] Feoktistov himself is an engineer who understands quite well, I believe, that the grievances here are not against our designers. After all, all the mistakes which have been committed during the process of the development of space equipment are within the limits of what is tolerable. But add to those mistakes the organizational and management mistakes, and it's that total that has led to the wasteful expenditures of colossal amounts of money. Just like everything else in our country, the space launches were governed by the masters of the "Grand Strategy."

[SOYUZ] Does that mean that, at the level of the design bureaus, plans existed which, after being approved "at the top," might have become a strategic space program?

[Yefremov] I think so. As far back as the early 1960s, our design bureau, under the leadership of Academician V. N. Chelomey, had worked out a long-range, integrated program for the use of outer space. The main thing was

that, based on a future line of development, the sequential development of a series of launch vehicles was called for—standard rockets with an increasing lift capacity of 3-4 tons (UR-200), 20 tons (UR-500) and 150-230 tons (UR-700). Extremely low costs and rapid rates of development were predetermined by, to a large extent, the high degree of continuity of the engineering approaches, the designs of the units, and so on.

[SOYUZ] You mean Sergey Pavlovich Korolev's design bureau didn't have such a program?

[Polukhin] You must understand that Sergey Pavlovich was a most talented design engineer and manager. But his program proposed that, after the development of the R-7—the 5-ton rocket which launched the Voskhod, Vostok, Soyuz, and a number of other craft—Korolev's design bureau would immediately set to work on the development of a 90-ton rocket! From the beginning, his idea seemed premature, but then the project was approved and received the designation N-1. The fate of that undertaking is now well-known to many people, although it took place, it is true, only after Korolev's death.

[SOYUZ] Yes, those explosions of the N-1 rockets, when we turn the pages of history back, cost us billions. But tell me, didn't the things that were being done by the design bureau headed up by Vladimir Nikolayevich Chelomey contribute to that either directly or indirectly? After all, your proposed UR-700 was supposed to carry a 200-ton payload and was the N-1's competitor. The former deputy chairman of the Military-Industrial Commission, G. N. Pashkov, complained in one interview that, in the early sixties, Chelomey shoved the firms of Korolev and Yangel into secondary roles and that the money allocated to them wasn't enough.

[Yefremov] It wasn't a matter of money. The failure of the N-1 project stemmed from a number of miscalculations. Our design bureau's program, in contrast to Korolev's, did not suggest such a terrible "jump"—his was by a factor of 20! Each of our launch vehicles was supposed to become part of a more powerful one. And the first stage elapsed without any kind of serious deviation from the "order." The first flights of the UR-200, UR-500 and UR-500 K (Proton) rockets were carried out over the three or three and a half years after we got the assignement to develop them. And how did we manage that? From the very beginning, our firm paid primary attention to the ground testing.

[Polukhin] For example, in setting to work on the development of the UR-500 K, we understood that its dimensions, unprecedentedly large for that time, would require greater reliability and less of a risk of the loss of craft of enormous cost. So as not to be engaged in completing the rocket "in the air," we invested our money in ground bench testing.

[Yefremov] You know, a good test stand can easily be equal to the device it's testing. That's where the money was "saved." During the development of the Proton (UR-500 K), in Dmitriy Alekseyevich's design bureau around 28,000 model and full-scale tests were conducted, and 16 full-sized test stands were developed in order to test the standard systems separately and joined together. Powerful computer hardware was used to simulate flight conditions. That virtually eliminated an expensive stage—the flight tests—and big savings in money and time were achieved.

As for the N-1, there are articles that note that, for various reasons, the chief designers greatly weakened the requirements for experimental ground testing. They believed that such testing would be long and costly. We all know what happened to the attempts to complete the N-1 "in flight." They couldn't handle that difficult task with the "jump." But some associates of Korolev's firm link the failure of the N-1 to interference by the firms of Chelomey and Glushko. To read that (in KRASNAYA ZVEZDA, 13 Jan 90) is somewhat hard to take—after all, everyone knows that all the work on the UR-700 was limited to the design and the mock-ups of certain sections of the rocket. That couldn't result in any sort of appreciable expenditures.

[SOYUZ] But what about your 200-ton rocket? What happened to it?

[Polukhin] The work on the UR-700 was begun in 196[illegible]. And, in principle, that is the best argument against those who are attempting to assert that our firm owed its successes, to a large extent, to the good offices of N. S. Khrushchev, whose son was an associate at V. N. Chelomey's Central Design Bureau of Machine Building. And even though they "killed" the UR-200 rocket soon after N. S. Khrushchev's removal, by then it was simply impossible to encroach upon the Proton—there was no alternative to it. And so we received the order for the 200-ton rocket and began working. And suddenly the specialists from Korolev's design bureau are writing a memo to the minister of general machine building, S. A. Afanasyev. Soon they "killed" our 200-ton rocket, and Korolev's people were left without any competitors.

[SOYUZ] A good many specialists have noted that, even today, we do not have much of a need for such a powerful rocket. Perhaps it is just as well that they "stopped" you at the Proton. In the meantime, can you tell us something about its "work record"?

[Yefremov] How about if I just give you a list. Since 1965, it has placed into near-Earth and other orbits the following space vehicles and stations: Astron 1, Vega-1 and -2, Venera-9 through Venera-16, Gorizont, Zond-4 through Zond-8, Kvant, Luna-15 through Luna-24, Mars-2 through Mars-7, Mir, Proton, Raduga, Salyut, Ekran and the large series of Cosmos satellites.

The launches of the Raduga system's vehicles, for example, have made it possible to abandon the expensive ground radio-relay communications links. Ekran provided television broadcasting via space to any point in Siberia. Gorizont made it possible to implement television and telephone communications with any point

in the world. It is because of the Proton rocket itself that, in our time, it became possible to bring lunar soil back to Earth, to begin a new stage in the study of Mars and Venus, to fly to Halley's Comet, to land spacecraft on the Venusian surface, and, finally, to place the heavy Salyut and Mir orbital stations into orbit, as well as the Kvant craft that support them. The versatility of this rocket is underscored by the fact that it places into outer space craft with the most diverse weight (up to 20 tons), size, inertia, dynamic and design characteristics. And with every launch, we recall the early 1960s, when the foundation was laid for those capabilities.

[SOYUZ] Yes, all this has been somewhat unexpected. Only now, it seems, after a quarter of a century, is the firm which provided competition for S. P. Korolev himself coming into our readers' field of view! Why that "period" of silence?

[Polukhin] Well, you didn't hear the name of Sergey Pavlovich Korolev very often in the mid-1960s, did you? Here I can't be all that harsh, because I worked in this field myself, but, in my opinion, right up to his death, because of his strictly regulated life, for the overwhelming majority of people, he remained a secret figure who, for a long time, was shown only from the back. V. N. Chelomey was also "classified."

[Yefremov] I don't want to give the readers the impression that the ground waves of space politics are associated exclusively with a confrontation between two personalities. Although, of course, that did occur, as did terrible wrongs. For example, we were developing the airframe of the first Salyut station when it was suddenly transferred to Korolev's experimental design bureau. A year later, it made its debut under someone else's name. But all that was from the waves of voluntarism and passions in management's upper echelon. When you look back, you're surprised at how often, at the top, unsound decisions were made which delayed for many years the realization of some of the space developments of our collective or completely stopped the developments. There's no doubt that it has to do with the subjectivity and incompetence of certain leaders. Our "evil genius" turned out to be the deputy chairman of the Military Industrial Commission, G. N. Pashkov.

It is a pity that the echoes of such an approach are being heard even today. Indeed, during the use of the updated Proton, the expenditures are turning out to be a billion rubles less than on the rest of the versions of the development of new heavy-lift rockets. However, the proper solution regarding the development is being unjustifiably dragged out.

[SOYUZ] You know, this drive of yours to get justice and to immediately realize something that wasn't permitted before frightens certainly not just me, but also many of our readers. You are, after all, "punching holes" in the sky. The ozone holes are being made by your [illegible]

[Polukhin] I can state, quite responsibly, that the effect of rockets in terms of the negative global impact on the environment is completely negligible! For example, the gaseous emissions from rockets are a thousand times less that those of aviation and hundreds of thousands of times less than those of motor vehicles and industry. There are local problems which are associated, first of all, with the need to expropriate large land areas around the test ranges and drop zones for the spent stages. It is precisely there where the spills of unused residues of fuel components occur. But even they are not comparable with the ecological damage from industrial waste, and, moreover, we have now worked out measures for the complete elimination of the spills.

[SOYUZ] An interesting picture. Aren't you, the leaders of firms that were so secret just six months ago, somewhat hard-pressed today to prove that space won't be a burden on us?

[Yefremov] I have a counter-question. You know how conversion is viewed in this country? Some want to put the highly intelligent collective that has been assembled on the same footing with an ordinary mass-production line. Some want, as much as possible, to curtail the programs which have even the slimmest possibility of being used for military purposes.

But for all that, it's time that firms such as ours were entrusted with just a little bit more independence—first and foremost, economic independence. After all, we have begun to establish international contacts, and the things we've developed—especially our launch vehicles—are in demand, but there is no definitive certainty that all the concluded contracts will serve the development of our firms and the preservation of the intellectual potential. The fact that the budget will be none the worse is fine. But that's today. If we are to have guarantees of profits from the space industry tomorrow, we must maintain the industry at the proper level by "granting," finally, fairly effective economic rights to the very developers of the equipment, too. In the meanwhile, in many firms, people have quietly moved "toward the exit." Understand, we are not saying: Give us more and more money. We will earn it ourselves and give the lion's share back to the country. But don't leave us with just a wage fund. And on that note, I think, we can conclude today's far-from-festive conversation.

Commentary on Competition for Commercial Space Markets

[illegible] Moscow IZVESTIYA in Russian 2[illegible] Jun 90 Morning Edition p [illegible]

[Article by [illegible], under the rubric "World Market: Trends and Predictions": "Trade Wars in Space"]

[Text] "Such [illegible] are being [illegible]. As before, they are an unfair and [illegible] burden for American commerce." Such is the usual complaint of American producers against competition from abroad. But [illegible] you think

we are talking about Japanese cars or Korean television sets, then you are deeply mistaken. The fact is that the U.S. aerospace complex cannot withstand the Chinese dumping in the field of commercial space launches of satellites.

The scandal in the world satellite industry, of which China's rocket building industry has become the hero, reflects only some of the problems caused by the stormy transition of space technologies to a commercial track. The space satellites market is, it must be said, very young, but it is one of the most dynamic and promising areas of the world economy. If 88 commercial satellites were placed into near-Earth orbits in the 1980-1988 for a total of $5.6 billion, then no fewer than 150 such craft will appear in orbit in the last decade of the 20th century, at a cost of $10-13 billion.

In the world today, there are four national or regional commercial space launch programs operating. The largest of them is the European program based on the Ariane rocket, which controls 50 percent of the market. Then come the Americans, operating within the framework of NASA, and the Chinese, with their Changzheng rocket. The USSR, which offers launches on the Foton rocket, is just beginning to develop its own space business. The United States leads in the production of the satellites themselves: the American firms of General Motors, Ford and General Electric account for 75 percent of the production. The greatest demand is for communications satellites—the "boom" in them will continue until the end of the century. The launch and operation of such vehicles is so profitable that, recently, the international communications satellites organization Intelsat announced that it would spend $150 million to set up a rescue mission in order to return its Intelsat-6 satellite to its designated orbit. The development of unmanned space laboratories is also considered a promising area, as is the development of environmental monitors.

Perhaps, it is the European Arianespace concern which most graphically proves the economic profitableness of the development of space and the lucrativeness of the "star business." From 1980 through May of 1990, the Europeans sent into space 83 satellites belonging both to countries and private firms, for an overall total of around $4.8 billion. The concern has a portfolio of orders for 38 more launches (of which nine were received between January and May 1990), at a cost of $2.7 billiondollars. In 1989 alone, Arianespace's pure profit amounted to more than $24 million.

The high level of earnings—as well as the no-less-important science-intensiveness—of the satellite industry, whose development makes it possible to spin-off advanced technologies and to stay on the cutting edge of technical progress, is contributing to the fact that more and more new firms, including those from developing countries, are dying to take part in the development of space. They are declining expensive, prestigious projects in favor of immediate practical assimilation of the results that have already been produced. For example, the Chinese—who (like the Europeans, by the way) do not even have to their credit the sending of a person into space or missions to the moon, but have, on the other hand, quickly adapted the existing achievements in rocket technology for the fastest extraction of profit—have emerged on the commercial launch market. That fundamentally distinguishes them from, say, the Soviet space program, whose leaders still cannot substantiate the economic return of the spending for space research and, with a most powerful production base and scientific potential, are still lagging behind other countries in the development of commercial flights.

But the market is not waiting—new formidable competitors are dying to get into it. As for the near future, the main events should probably be expected in Japan. A rapid breakthrough on the space technologies front is being planned there. Even now, Japan itself is producing satellites, supplying the United States with engines for space rockets, and developing its own powerful N-2 launch vehicle. In preparing for the next economic offensive, the Japanese companies are planning to form a powerful consortium of 70 firms, which will include such giants as Mitsubishi Jukogyo [Mitsubishi Heavy Industries], Toshiba and Nihon Denki [NEC]. The consortium's goal is the development of a "space superfactory" for the production of satellites and rockets.

India, which has in orbit one satellite of its own manufacture, is energetically developing the production of rocket and satellite components. In the next few years, the Indian Space Research Organization is planning to spend 35 billion rupees for the purchase of equipment needed for space research, and 30 percent of that equipment will come from Indian companies. In 1992, Brazil will launch its first satellite from its own territory, although, it is true, it will be with the help of the Chinese.

As young as the space market is, it is slowly beginning to be shaken by the storms customary for any economic system. Under pressure from the Americans, Japan, which, barely having entered the pool of space powers, immediately protected its producers from foreign competition, was recently forced to open up its own market for satellites from the United States. In the meantime, of the 43 Japanese satellites operating in orbit, only 5 have been bought from American companies. Today, everyone is disturbed by the conduct of the Chinese who, despite agreements signed in 1988, are selling commercial launches for a price of $20-30 million, whereas the same procedure in either Europe or the United States costs $50-100 million. But then, the appearance of the Soviet merchants with the Foton system is still awaited on the market. And here is what is strange: for some reason, no one doubts that the Soviet businessmen will also be practicing the [illegible] condemned practice of dumping.

Foreign Interest in Soviet Space Systems Noted

PM0210122590 Moscow Television Service in Russian 1700 GMT 27 Sep 90

[Report by P. Orlov, S. Murazov, A. Zubov; from the "Vremya" newscast]

[Text] [Announcer] The cargo spacecraft Progress M-5 was launched in the Soviet Union today at 1437 hours 40 seconds. Thus the realization of the dream of a factory in orbit is getting nearer.

[Reporter] You see the launch of the transport spacecraft Progress-M5. It is the first cargo craft capable not only of delivering goods to the space station but also bringing them back to earth. And there are things to bring back—crystals grown in space. Gennadiy Manakov and Gennadiy Strekalov are packing them aboard the station now. If they had to bring these cases back to earth in their own craft, there might not be enough room for the cosmonauts themselves.

[Orlov] This capsule can bring up to 150 kg of freight from the "Mir" station back to earth on the Progress-M5 spacecraft.

This is our space reality, both as regards science and the attempt to recoup, albeit partially, the costs, at least on the internal market.

However, in the international division of labor in space this is also one of the most promising spheres for our country. At the "Aerospace" exhibition while preparations for this launch were under way, it was announced that the unmanned factory satellite Photon had successfully returned to Earth from space with crystals grown there for two weeks under contract with the Munich Kayser Threde company. Such commercial deals bring in foreign currency even though, because of our past secrecy and countercurbs on the lines of the Coordinating Committee for Multilateral Export Controls [COCOM], we have in many respects come late to the sharing out of the space cake. Half of it has already been grabbed by the French, who occupy first place in the sphere of commercial launches. But the market is the market. And the French have turned to us with a proposal to test their future multiple reentry vehicle—Hermes—on the basis of our TsNIIMASh [Central Scientific Research Institute of Machine Building] space institute. In this way the Soviet test base may be used to our and our Western partners' advantage while waiting for the Buran. Interest in our propulsion units is also growing. And an agreement is being drafted under which the British Hotol craft is to be launched from our Mriya. It was announced recently that we will know the results of these negotiations in six months' time. It promises to be a multibillion deal.

It would be wrong, of course, to expect total self-capitalization from space research and similar spheres. Science has always been funded by the state. But if it can bear fruit right now, why not?

So we are not the only ones following the flight of the new Progress-M. Many people abroad would also like to obtain materials from the world's only space station. Docking with the Mir complex is scheduled for this Saturday.

USSR Seeks Mexican Satellite Launch Contract

PM0811100290 Moscow IZVESTIYA in Russian 7 Nov 90 Union Edition p 4

[Dispatch by correspondent A. Cherepanov: "Will Our 'Proton' Win?"]

[Text] Mexico City—Our country has a unique chance to enter the international commercial market of space goods and services. If this happens, it will be in Mexico. The Soviet Union together with other countries will participate in a competition to launch the third Mexican communications satellite as part of the "Solidarity" program. The Main Administration for the Creation and Utilization of Space Technology is putting forward the delivery vehicle "Proton."

The working life of two Mexican communications satellites which have been in geostationary orbit for many years, is running out. The Mexican Government has decided to announce an international competition to design a satellite and launch it using a foreign delivery vehicle.

The Soviet side is only participating in the second part of the competition. Back in July of this year, a delegation from the Lavochkin Science and Production Association visited Mexico in order to present the "Proton" delivery vehicle. It was headed by V. Serebrennikov, acting general designer, and V. Asyushkin, chief designer. From their viewpoint the presentation went off successfully. And right away in August, the Mexican specialists made a return visit to the USSR.

Does "Proton" have a chance of winning the Mexican competition? After all, it has fearsome rivals in France, the United States, and China. It does have a chance, and a good one, according to both Soviet and foreign specialists. At present, our delivery vehicle has no equal in the world as regards its technical characteristics. If you look at Western assessments, it also overtakes its foreign counterparts in reliability. Only "Proton" has had over 100 launches, almost all of which were successful.

"Proton" is the only vehicle of its type that is able to take satellites directly to geostationary orbit. This means that the satellite does not need its own engine, whose fuel accounts for up to a third of the weight (600-700 kg) of the complex that is put into orbit. It is not difficult to see that if "Proton" wins, the Mexicans will also automatically be able to increase the payload of their satellite and prolong its time of activity in orbit by several years. But...

There is a circumstance that casts doubt on the probability of the Soviet delivery vehicle's victory in the

competition. I have in mind the U.S.-NATO embargo on importing to the USSR many types of electronics and equipment "of strategic importance"—after all, the satellite will have to be launched on Soviet territory, at Baykonur. The Soviet side has long been giving guarantees of the safe transportation of satellites on the country's territory and the presence of representatives of a Western firm at all stages—from the transportation to the actual installation and launching.

Specialists from the Lavochkin Science and Production Association believe that the Mexican competition is essentially the only chance for us to put our space goods into the international arena. It is predicted that soon the developing countries will not be placing such orders.

Leonov Interviewed on Soviet Manned Lunar Program, Current Issues

907Q0151 Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 8, Aug 90 pp 44-45

[Interview with Maj. Gen. Avn. Aleksey Arkhipovich Leonov, USSR Pilot-Cosmonaut, twice Hero of the Soviet Union: "The Flight That Didn't Take Place: Maj. Gen. Avn. A. Leonov, USSR Pilot-Cosmonaut and Twice Hero of the Soviet Union, Talks About the Soviet Lunar Program and Current Problems of the Space Program"; the remarks of interviewer Maj. I. Kuznetsov appear in bold]

[Text] **Aleksey Arkhipovich, the readers of our journal are interested in the "blank spaces" in the history of the Soviet space program. One of them is our manned lunar program, in which you had the occasion to be a participant. Please share your recollections with us.**

The Soviet manned lunar program called for two phases: first, a flight around the moon and, second, the landing of a man on the moon. The technical director of the program was Hero of Socialist Labor Vasiliy Pavlovich Mishin.

The first phase, in the mid-1960s—which is when the specialists at the Center actually became involved in the project—was seen as a reality: the Proton launch vehicle had already flown, and the Soyuz vehicle, which had received the designation L-1 in its lunar modification, was taking shape in metal. The second phase, however, was problematical. Still, we believed that it would come off. Sergey Pavlovich Korolev, even before the decision was made to implement the lunar program, had told us of the powerful N-1 booster and the L-3 vehicle, whose development his team was working on. At the time, we thought that the lunar program was designed to span many years. Plans for the creation of lunar settlements and for flights to the planets of the solar system were being debated. There was all of that, but reality demonstrated that our dreams were getting far ahead of workable events.

The booster that was to be used to effect the program of circumlunar flight had been built and had proved itself admirably. However, the first launch of Zond—that's what the unmanned version of the L-1 was called—was unsuccessful. Why? In order to attain escape velocity, a boost module (the D module) had been installed on the Proton, but the command switching was mixed up, and instead of an acceleration we got a deceleration. The vehicle had to be destroyed. This was the first danger signal. The next launch went well, but then there was another malfunction in the booster. After working for several seconds, it dropped a short distance from the launch site. It turned out that a rubber plug had gotten into the manifold just ahead of the turbopump assembly. Becoming stuck in a duct in the pump, it cut off the fuel supply. After that, major malfunctions resulting in aborted flights occurred every other flight.

In 1968, it became clear that we wouldn't accomplish the task before the Americans did. One reason was the lack of proper financing and the improper allocation of funds.

You said that the main efforts were devoted to implementation of the L-1 program? How were the cosmonauts trained for that?

In all, nearly 20 people were training for the lunar program. The first crews—Leonov and Makarov, Bykovskiy and Rukavishnikov—were formed from among them. The entire group, believing that the goals that were set were achievable, worked diligently, for each one thought that, if the circumlunar flight were successful, he would automatically move on to the next phase with the L-3. Therefore, the training looked toward the future. We mastered many simulators, including a dynamic simulator that was built from a helicopter, and went through the test-pilot course at the Flight Research Institute. Realizing that the most difficult task would be the landing on the Moon, we learned how to quickly pick out an area and set down the craft with limited fuel reserves and how to instantly estimate vertical velocity.

Upon returning from the Moon, the landing approach was supposed to be from the direction of Antarctica. In order to learn the constellations in the vicinity of the Southern Cross well, we even flew to Somalia. For independent navigation, the vehicle was outfitted with an astrotracker and sextant, and the cosmonauts devoted much time to the study of those instruments. In the final analysis, everyone learned to work with a complete understanding of the dynamics of circumlunar flight.

To perfect the landing on Earth from escape velocity, the specialists developed a clearcut, detailed procedure with two immersions. We had to learn how to use the astrotracker and sextant to select the angle of entry after the final correction. And the proper angle depends on the magnitude and direction of the retrothrust impulse. If the angle is too large, the vehicle may "dig into" the atmosphere. If it's too small, the vehicle can "overshoot" the atmosphere. The best version is an entry with a "skip": you enter the atmosphere, skip it, and, after losing high velocity, enter again, all the while keeping to

mind which angle of attack the vehicle must maintain to reach the designated touchdown point. The "Manual Impulse Entry" instrument flashed the number of impulses after covering the first segment. We also used it to figure out the distance to the designated touchdown point. The distance was then converted into an angle of attack. All those operations were perfected in the dynamic "Volchok" simulator. In the end, we learned to make a "landing" with a precision of within a kilometer. After passing examinations on the design of the vehicle and the flight program, the cosmonauts were ready for circumlunar flight.

The flight would be difficult, even in terms of just the living arrangements, because, unlike Soyuz, the L-1 did not have an orbital module, and two people would have to spend a week in the descent module. We had high hopes as we watched the last unmanned flight. But, when the nose shield was jettisoned, a command was also sent to jettison the parachute system. The ship hit the ground and was flattened. Curiously, some of the film that it was bringing back was intact. As a result, we were the first to get beautiful, extremely clear photographs of Earth from the Moon.

In December 1968, the Americans performed a circumlunar flight with Apollo 8, and our leaders were shaken. "Do we need to do it now? General Designer Mishin nonetheless managed to perform one more test flight of the unmanned version. And again a failure. Problems with the flight configuration led to depressurization of the craft. I should add that all three launches of the N-1 booster rocket in the flight-design testing were unsuccessful. Soberly sizing up the situation, the government shut down the program for landing a man on the Moon.

Aleksey Arkhipovich, was our plan any different from that of the Americans?

Our lunar lander was similar to the American lander, and the flight plans, as envisioned even by Kondratyuk, were in no way different from theirs. The craft had to attain a circumlunar reference orbit, and a capsule would separate from it and make a soft landing on the Moon. It's true, though, that unlike the American plan, ours involved landing just one person. But the operations on the Moon and the return to Earth were exactly the same.

I remember that the Soviet Union was conducting investigations of the Moon with unmanned satellites at the same time. They provided us with interesting information that was even more complete than what the Americans had at the time. But there was one other difference.

The accident aboard Apollo 13, involving an explosion of a fuel element, demonstrated the very flexible thinking of the American leaders. Having been honest in giving out all the details, they were able to rally the entire nation at the time. Literally all of America was watching that mission, living through it, thinking about how to rescue the crew and making suggestions. But we always hushed up our emergency situations, trying to show the superiority of Soviet engineering. In actual fact, we had many more emergencies than did the Americans. But that wasn't told to the people. Therefore, many got the impression that the development of outer space was a rather simple affair, and that the upkeep for the cosmonauts was costing the government a lot and was economically unjustified.

How did you follow the execution of the Apollo program by the Americans?

The entire world, except for the Soviet Union and China, watched the first step of man onto the Moon. But none of the Soviet people, except for at most a hundred people watching the news reports in one of the organizations, saw the launch of the craft, its landing on the Moon, or the activities of the crew. History has rightly judged our ideologues, Ponomarev and Suslov, and the course with which they guided the country. But the Americans have no false morality. In 1965, they gratefully accepted all our information on the walk in space and coordinated their own program with it. If at first they had planned to have an astronaut just stick his arm out of the craft, now they duplicated my space walk and even used a hand-held space gun that enabled the astronaut control his body somewhat in space. Returning to the American lunar program, let me say that there are no "blank spots" in it for me. Moreover, I have the flights of Apollo 10 through 17 saved on video cassette.

And have you seen any extraterrestrials in your films? The UFO watchers claim that the first men on the Moon saw them, and that extraterrestrials were watching the astronauts. Is this true?

Those who are prone to every kind of sensationalism have taken a phrase in the astronauts' conversation out of context and are building their fantasies on it. After the landing on the Moon, clear communications were set up with the flight control center in Houston. A picture was sent to the Moon and back. Neal Armstrong, exiting from the ship, stepped onto the surface very carefully, and then he grew bolder, and his steps became more confident, and he began to jump. I've seen those frames. James Aldrin, turning to him, said, "Look out, they're watching us." "They" in the sense of "Earth." Then he advised Armstrong not to violate the instructions and to be more careful. And in fact, after that, Neal Armstrong began to walk with normal steps. I have told the UFO watchers repeatedly, "Why are you speculating about this? It's not at all what you think."

We have created the reusable Buran, it has gone through the first tests, and now some—for example, Academician Sagdeyev—say that we don't need it. What is your opinion?

We have the Mir program. If we really want to collect dividends, we have to be able to bring back to Earth the materials involved in the research that is carried out. The Soyuz craft can return a small volume of cargo that weighs a maximum of 100-120 kg. We are planning to return tons. Only Buran can do that. In light of that, I can't agree with Sagdeyev when he says that there's

nothing for Buran to do in orbit. We need it as a component part of the transport system of the Mir program. Sagdeyev is not right here.

On top of that, he was silent before now, and now he is raising objections. It would be more ethical on his part to be giving an accounting for his own project: why did the Phobos vehicles, which he launched and in which large sums were invested, fail before reaching their target?

This, it seems, would be a good place to touch on the matter of improving the profitability of space?

The space program, being the embodiment of the leading scientific and engineering thinking, is indeed capable of a much larger economic return. The Americans, after spending $25 billion on the lunar program, subsequently made a profit twice that figure through the introduction of new technologies and developments. The situation is somewhat different with us. But whose fault is that? The space program's?

As far back as the '30s, Academician Kapitsa posed this question to the economic council of the Sovnarkom: What incentives for adoption of new inventions are built into the Soviet system? And he answered the question himself: "I see none." The situation has not changed since that time. What projects have the economists not justified to please the politicians—"depeasantization," the "elimination of unpromising villages," the "redirecting of the courses of the northern rivers," and other pitifuly memorable projects. And to this day, there is no economic mechanism to encourage enterprises to adopt new products or technologies that, in abundance, lie unclaimed in the space sector, for example. That is where the talk of the poor profitability of space comes from. But that's not the space program's fault—it's the space program's misfortune.

I remember how we were asked to monitor farm lands from space. In a matter of days, we produced a mountain of information, but it differed by 25-30 percent from the amount issued by Goskomstat [State Committee for Statistics]. And they refused our services. We explained that many of the fields are either smaller than indicated by the data of the Agroprom, or are not being used, and therefore were not included in the reckoning. The results of mismanagement are also very visible from space: pastures trampled down, rivers and ponds ruined, the air in cities polluted. We can talk about all the outrages committed on Soviet soil, for example, by the Ministry of Land Reclamation and Water Resources. There's a lot of talk today about the Aral Sea and Lake Balkhash. And yet, the cosmonauts were the first to sound the alarm, 15 years ago. I myself went to Pelsha, the chairman of the Party Control Committee of the CPSU Central Committee, and told him what was happening on the Baykal-Amur Railroad and at the Aral Sea. Although certain decisions were made with regard to the Baykal-Amur Railroad, nothing has been done for the Aral.

It seems that no one has any use for our information. I personally feel that it is primarily the economists who should be reproached for that. And here the press should place the emphasis where it belongs. Good communications are needed, in both directions, and then there will be an economic impact.

And the last question, often asked by the readers of our journal: Do you think those of us living today will witness the realization of a Soviet lunar program?

No such program is envisaged before the year 2000. After that, we shall see.

Funding Problems Hinder Use of Radio Telescope

PM2609134290 Moscow Television Service in Russian 0830 GMT 25 Sep 90

[Interview with G.Ya. Smolkov, doctor of physicomathematical sciences and acting director of the Siberian Radio Astrophysical Laboratory by V. Kodkin, from the "Vremya" newscast]

[Text] [Announcer] Despite the fact that the USSR Academy of Sciences has all the material resources at its disposal, lack of funding is still taking its toll on the development of basic research, in particular, on the new radio astrophysical laboratory under the Siberian Institute of Earth Magnetism, the Ionosphere, and Wave Propagation.

[Kodkin] Scientists call it the solar laboratory for short because its purpose is to study the star closest to us. It is observed using a unique instrument—a radio telescope with a reflector 622 m in diameter formed by 256 radio antennae. That is the number of sharp eyes that converge on the sun with equal curiosity and attention in any weather. It is well known that we live in an atmosphere ruled by the star which gave us life. And everything is dependent on its behavior—the climate, harvests, our own health, and, lastly, our longevity. It is a shame that the gigantic radio telescope near the city of Sayan, which was developed to carry out in-depth basic research, is only exploited to five to 10 percent of capacity. Will the observatory there be able to enhance the effectiveness of its research?

[Smolkov] The mechanism for funding basic science is well known today. Many of our associated organizations, many of the observatory's practical and academic institutes are all worrying now and are in a very difficult situation with regard to labor remuneration and supplies because they also lacked funding in the past. Ties with interested sectors are lessening in connection with the fact that conditions of funding are also interfering in the activity of interested parties and leading organizations. A truly unique solar observatory is being born amid the torment involved in the transition to the market. Will it be viable? Yes, provided that we think about the future while in the midst of our current problems.

'Rethinking' of Space Program Described

LD0510021790 Moscow in English to Great Britain and Ireland 2000 GMT 2 Oct 90

[Excerpts] The 33rd anniversary of the launching of Sputnik, which marked the birth of the space age, finds the Soviet space community in the grip of profound soul searching as it rethinks the future of its space program. This is the subject our science correspondent Boris Belitskiy speaks about in "Vantage Point" tonight.

[Belitskiy] [passage omitted: Following Sputnik's launch the Soviet space program became something of a sacred cow, protected by the secrecy of that time—this is now a thing of the past. Examples of current press criticisms.]

While some of the criticism is far from convincing, there is no denying that regardless of its rights and wrongs, its cumulative effect has been to set in motion a profound rethinking of the Soviet space program. One point now accepted on all sides is that the space program is in urgent need of a new decisionmaking process.

The present highly centralized command structure of the rocket and space industry came into being with the cold war, for the prime purpose of creating a dependable nuclear missile shield against what the country's leadership of the time perceived as an American threat. But as the space became multi-pronged and more sophisticated, with the number of options available increasing, its extremely centralized command structure, fenced off from all criticism, began to take wrong turns, and the present climate of glasnost or openness is at last making possible long overdue exposures of such cases which resulted in heavy financial losses and thereby imposed additional strains on the economy. [passage omitted]

Although no new space program has yet been officially finalized, certain basic elements of it have emerged from current discussions on the subject. It will certainly retain its elements of basic research in astrophysics, planetology, physics of the earth, biology, medicine, and other sciences. There will be a big emphasis on elements designed to serve the country's economic needs: communication and weather satellites, earth studies and the like. New types of space transport systems will be developed, probably including a space plane, and of course the space program will include certain elements to meet the Soviet Union's defense needs, which will for obvious reasons be classified, but will most certainly fit into the overall new Soviet military doctrine of reasonable sufficiency.

Such, briefly, is the kind of space program we can expect to emerge from the current debates on the subject, 33 years after the electronic beeps of Sputnik heralded the birth of the space age.

Missiles May Be Converted for Civilian Use

PM1510121790 Moscow KRASNAYA ZVEZDA in Russian 11 Oct 90 First Edition p 4

[Letter from reader and response by Major M. Arkhipov under the "Briefing for Readers" rubric: "Is It Worth Destroying the Missiles?"]

[Excerpts] It is well known that Titan-2 ICBM's are used in the United States to launch payloads into space and that it is planned to use MX ICBM stages in the future Taurus carrier rocket. Is similar work being carried out in our country?

[Signed] Senior Lieutenant L. Shimanovskiy

Major M. Arkhipov, senior officer of the press group of the chief of Defense Ministry space units, says: "[passage omitted] Our specialists are also carrying out work in this direction. At a difficult time for the country there is no point in destroying enormous material values by blowing them up or crushing them. The technical side of things requires that a number of structural modifications be made to the ICBM stages, and that a cycle of ground and flight tests be carried out to confirm the effectiveness of these modifications.

"Within the framework of the conversion of strategic offensive arms it may be that with us too new carrier rockets will appear which are capable of resolving scientific and national economic tasks."

NPO Polet Adversely Affected by Conversion Program

917Q0016 Moscow SOVETSKAYA ROSSIYA in Russian 10 Oct 90 p 1

[Article by S. Shkayev: "Siberian Rocket Specialists"]

[Text] At the Omsk Aviation Plant they used to produce the high-speed Tu-2 bombers and Yak-9 fighters. In the post-war period , up to the mid 1950s, they produced Tu-104 airliners. Then the enterprise changed its aviation profile and, having become completely secret, it worked on rocket and space programs. Many residents of Omsk didn't even suspect that the "Polet" association was producing the bodies of space apparatus for studies of the Moon, Venus, and Mars.

However, the "Polet" association has many problems. And some of them, strange as it may seem, are connected with conversion, which has had a negative effect on the above named peaceful programs. The capacities of this powerful scientific-technical complex are not being utilized to the fullest extent. The program for production of unique engines, which, by the way, could be profitably sold for currency, has been cut back. Hundreds of the most experienced professional staff have been shifted to production of simple consumer items. In my opinion the Siberian rocket specialists will not gain world renown for themselves with these "thousand trifles" neither in our own market nor, even more so, in the Western market. It

An engine for the universal rocket booster Energiya

is not by such unsophisticated production that the might of Russian should increase, but by the science-intensive space technology of Siberia.

Continued Development Urged for Nuclear Power Sources for Spacecraft

907Q0135 Moscow PRAVITELSTVENNYY VESTNIK in Russian No 26, Jun 90 pp 6-7

[Article by German Lomanov: "Would It Be Comfortable Living Beneath a 'Nuclear Umbrella'?"]

[Text] **A satellite with a nuclear reactor aboard circled above the planet, slowly losing altitude. For almost five months, the ground services tried to move it to a safe orbit. They were unsuccessful—communications was lost. When just a few days were left before it would re-enter the atmosphere, the protective system was automatically activated, and the craft sped upward, to an orbit in which it would remain for around 300 years—within that time, the radioactive isotopes would decay completely.**

That is not a call for scripts for a suspense film. It is an actual case that occurred two years ago with Cosmos-1900. In the train of the tumultuous events of our lives, it passed unnoticed; only specialists knew of the alarming situation, and, thank God, everything came out all right. Had things gone otherwise, there would have been no avoiding a scandal. Like the one in 1978, when radioactive fragments of the Cosmos-954 satellite fell on Canadian territory, and the Soviet Union had to make a substantial financial compensation for the damage it caused.

For the sake of objectivity, let me note that accidents have occurred on nuclear-powered American spacecraft as well as on ours.

Around 60 craft carrying nuclear power sources have been launched into space over the last 30 years, and about 10 of them have found themselves in more or less serious emergency situations. The statistics don't inspire optimism. When you imagine a sort of "nuclear umbrella" over your head, with holes in it, you can't help exclaiming: "Why is all of this necessary? There are enough accidents with nuclear power plants as it is on the ground, and now we have them in space as well."

But then there is also another point of view: For safety's sake, let's put all nuclear power plants in space—why accumulate radioactivity on Earth? And technology will somehow find a way to transfer energy from orbit directly to consumers. That idea seems to be a fantasy today, but who can say that it may not become reality in a hundred years or so?

But let's return to our rebellious century, and for a start let's go through the statistics. First of all, radioactive releases didn't occur in all the emergency situations. Second, not nearly all of the 60 craft are circling over our heads, even if in safe orbits. Such craft include the Apollo vehicles and the unmanned Pioneer, Viking and Voyager craft, also equipped with nuclear power sources. Those craft completed unique scientific tasks, and their payloads have long been on the Moon or on Mars, or beyond Uranus or Saturn. Third, for two years now already, no country has launched a nuclear-powered spacecraft. This is a perfect time to capitalize on this break and weigh all the pros and cons.

I must admit that I don't like the emotional outbursts of "public rally" science, which unfortunately has been taking center stage more and more frequently in recent times. And at the same time, I can't understand the cold arrogance of official science, which would never stoop even for a moment to explanations in layman's terms. We lose a great deal because of this reluctance (or is it inability?) to talk with the most ordinary people, who might not know very much, but who are trying to understand things. We are losing perhaps the main thing—the opportunity to shape sensible public opinion. Not that anybody was ever interested in doing that before. But at this point in time, 30 years later, let's try to talk simply about complex things, and let's imagine a hypothetical discussion between a curious and unbiased reader and a competent and objective physicist. Here goes...

[Physicist] I wouldn't advise that you panic when you see sensationalist headlines like "Reactors Over Our Heads." What is important is not the fact that they are above us, but how high or how low they are. If, for example, we were to launch a craft into an orbit 800 kilometers from Earth

it would stay there for several hundred years. During that time, all the dangerous isotopes would decay. The higher the orbit, the longer it would stay up. I hope that it's understood now that safety is automatically ensured for a spacecraft carrying a nuclear power source if the ballistic characteristics of the craft's orbit preclude its falling to Earth?

[Reader] Everything seems all right in theory. But why, then, did our Cosmos satellites fall from such a height?

[Physicist] The fact is that they didn't fall from such a height. Satellites with nuclear power sources were used in defense programs—their radars tracked ship movements. They were flying at an altitude of approximately 250 kilometers, gradually descending as a result of atmospheric drag when their engines weren't in operation. When the danger of approaching a critical point arose, an engine was switched on, and the satellite was returned to a safe orbit. There is a risk here—if a command fails to reach the craft, of if the craft is positioned incorrectly, it will go down instead of up. But if it is inserted into a high orbit from the very start, the risk is negligible.

[Reader] Is that so? But what if two satellites collide, or what if a meteorite hits the craft?

[Physicist] That's not likely—after all, space isn't like a busy highway. Moreover, they wouldn't collide head-on like two automobiles. Don't forget that spacecraft are launched in one direction—with their inclination matching the Earth's rotation. They rush around the planet at enormous velocities, but they move slowly in relation to one another. Think about how softly and smoothly spacecraft moor with a station during the docking procedure. Meaning that even if they did collide, such contact would hardly do any serious damage to the spacecraft.

A meteorite? The probability of a hit is extremely low. But something else is more important. You have been made to believe that a collision or a meteorite would be disaster. But little is said to you about why that would be so. Yes, an accident in orbit would be a disaster, because it would put out of commission a spacecraft in which considerable amounts of money have been invested. But its fragments wouldn't fall to Earth until hundreds of years later, after the radioactive isotopes have already decayed. And those in geostationary orbit would remain there practically forever. Incidentally, geostationary orbits are precisely what developed countries are currently interested in—"staking a claim" out there is not an easy thing to do.

[Reader] A cosmic Klondike? What makes a geostationary orbit, and why is it so tempting?

[Physicist] It's an orbit with an altitude of 36,000 kilometers. The spacecraft's angular velocity out there is the same as our planet's. To put it more simply, a satellite up there makes one revolution every 24 hours, which means that it "hangs" over the same point on the equator all the time. It's an ideal place for various relay stations, making it possible to create planet-wide communication, television and information systems. It is those kinds of stations that need powerful, long-lasting power sources.

[Reader] I can see where you're going. I'm even ready to agree with your concept of safe orbits. But first you have to get there. An accident could occur on the way to the cosmodrome, or on the launch pad, or during orbital insertion.

[Physicist] That's true. Let me add that it is precisely at those times that the danger is greatest. Nonetheless, it differs for the various types of nuclear propulsion units. For its spacecraft, the United States uses sources based on the plutonium-238 radioisotope, which is produced in ground-based reactors. That isotope is highly radioactive—its handling requires the greatest precaution from the very outset, and an accident at any stage could mean big trouble.

Soviet space reactors use uranium-235, whose radioactivity is relatively low. Were such a device to completely disintegrate on Earth, only a minor amount of local contamination would result. Let me point out for the sake of comparison that the water in the oceans contains billions of tons of uranium compounds. Biologically dangerous isotopes begin to appear only after the reactor goes into operating mode. But that would not happen until the spacecraft was in orbit, and radioactive "contaminant" wouldn't get to Earth from there.

[Reader] Nonetheless, we are told that an accident involving a space reactor is comparable in its consequences to the Chernobyl disaster.

[Physicist] You think so? Well, let's compare the figures. The thermal output of the Chernobyl reactor was 3,000 megawatts, or 3 million kilowatts. That of a space reactor (I'm referring to one already in orbit) is approximately a hundred kilowatts.

[Reader] Does that mean that in order to create power production capacities in space equal to one reactor of a ground-based nuclear plant we would have to launch 30,000 nuclear-powered satellites?

[Physicist] Precisely. But we don't need that much—a hundred would be more than enough to handle our priority objectives.

The arguments of physicists might seem persuasive to some, and debatable to others. At any rate, let's interrupt this dialogue, now that we have come to the main point. Is there really a need for nuclear-powered spacecraft? When the United States was conducting research in its SDI program, such a question wasn't worth asking. Nuclear-pumped X-ray lasers, orbiting stations operating in the "Alert" mode for years on end—all that required considerable energy outlays that could be provided by nuclear power plants only. But now...

"When we discussed the results of previously classified research a year and a half ago," said Academician N.

Ponomarev-Stepnoy, first deputy director of the Institute of Atomic Energy imeni I. V. Kurchatov, "we already knew that our country would be shutting those defense projects down. We suggested to the Americans that we cooperate in providing energy to space flights that were needed by the people. But then some of our newspapers accused us of helping the United States create SDI, even though the proposals had to do with civilian and commercial programs—in a word, absolutely peaceful programs. Then a year later at a scientific conference, the Americans told us in no uncertain terms that the USSR's peace initiatives and our openness were responsible for the disintegration of SDI as a specific defense program, and that the proram was becomeing more of a conventional research project. As we know, President Bush proposed an expedition to Mars as a possible alternative to SDI. Not a bad sort of conversion, is it?"

I don't know. Personally, such a mission, which would be carried out solely for the purposes of prestige, doesn't inspire me. The scientific results probably won't be commensurate with the outlays—the Apollo program proved that. Moon walks in space suits were about as sensational as you could get, but serious scientists shrugged their shoulders—they learned nothing essentially new about our natural satellite. Of course, there have been some "spin-offs"—transfers of technology from space to conventional industry. But if you want to touch your right ear with your left hand, why go around the back of your head? Wouldn't it be simpler, and faster, to create such technologies for conventional industry in the first place? Perhaps the Americans can allow themselves to spend such enormous amounts of money on such a mission, but not us, with our empty shelves....

"Wasn't our country really any richer when Tsiolkovskiy dreamed about space settlements, and Tsander exclaimed, 'Onward, to Mars!'?" objects Nikolay Nikolayevich [Ponomarev-Stepnoy]. "Who would have believed then that the space program would become a mighty, developed and, incidentally, profitable sphere of human activity? But all right, let's put 'fantasies' aside although I'm convinced that we can't live without them and that no sort of prohibitions can put an end to the desire for knowledge. Let's talk about what's happening today. For example, the Americans are currently working on the Intelsat-6 communications satellite, which will provide communication via 30,000 telephone channels. They are now studying various hardware for putting it into geostationary orbit. We discussed the following idea with them—the U.S. can place Intelsat in an orbit with an altitude of several hundred kilometers, but our 'space taxi,' equipped with a nuclear power source and a plasma electric propulsion engine, could haul it up to a geostationary orbit."

"That would be a long trip...."

"Yes, at least a year. But that doesn't bother them. Intelsat is designed to operate for 15 years, and they wouldn't mind waiting just a year. On the other hand, according to their own calculations, the 'taxi' would cost less than a booster unit. Space tugs, global systems for communication, television, and navigation; disarmament verification and monitoring of the environment—there are plenty of purely peaceful and very much needed practical tasks to be done in space orbit. But there aren't many kinds of energy sources—chemical, solar, nuclear. Chemical sources don't last long, and solar arrays also degenerate rather quickly. The larger the area of the photocells, the heavier the array and the poorer maneuverability of the spacecraft. Moreover, beginning at around 10 kilowatts of power, nuclear power becomes cheaper than solar power. And in light of the fact that every 'solar' kilowatt in space costs around $1 million, the advantage of nuclear power, you must agree, is substantial."

I can understand Academician Ponomarev-Stepnoy's concern, his anxiety over what will happen to the Institute of Atomic Energy in a market economy. A great deal of the institute's research is basic research. There will hardly be a demand for work of that sort in our market in the next few years. That's a pity, and here is why.

The citation index—the number of references to the work of an author or of an entire collective—is usually used to assess scientific results. For example, according to that indicator, the Atomic Energy Institute is in fifth place among Soviet scientific institutions—that, by the way, is an assessment by the Americans. And in space nuclear power engineering, the institute is the acknowledged leader. Experiments involving the creation of a space-based nuclear power source employing thermoelectric energy conversion—the Romashka—were started back when Academician I. V. Kurchatov was still alive. Further development of this research led to the creation of space reactor units. Soviet scientists and producers can be proud of the unique nuclear power sources employing thermionic energy conversion of the thermal energy of a nuclear reactor into electrical energy. During this five-year plan, in actual space conditions, demonstration tests of the Topaz device showed its efficiency and productivity. The sector possesses a creative, scientific, technological and production foundation that can ensure wide use of Topaz devices in space technology. It is very important to note that results obtained by Soviet scientists are substantially above the world level in this area. Our competitor—the United States—after spending nearly $1 billion on such work, still hasn't created a workable, efficient unit.

Space-based nuclear power engineering is, in general, one of the most science-intensive sectors, and in it are concentrated highly qualified scientific, technological and production forces. Judge for yourself: The highest temperatures in the thermal cycle of ground-based nuclear power plants is approximately 300°. The coldest part of a space-based nuclear reactor is heated to 500°, and energy is produced at a temperature of 1700°. When the reactor is operating, the whole thing shines, it glows.

And it works in automatic mode, without human intervention. Imagine the unique technology and the unusual materials employed in it. Can this masterpiece of creative thought really be a dead-end branch of scientific and technical evolution? Have the years of work by the most talented of researchers really been for naught? I don't want to believe that. But it's something we need to think about.

I am not going to conceal the fact that reactors were created for military facilities. But now is the time of conversion. But is it going as it should? Academician Ye. Velikhov, director of the Atomic Energy Institute and a USSR people's deputy, spoke convincingly of the shortcomings of conversion in a speech to the second session of the USSR Supreme Soviet. Take just the aviation industry. In the West, there is a demand for Soviet airplanes and helicopters, the cost of which in convertible currency is considerably higher than our labor outlays. But our planning organs are cutting back the production of aviation equipment, using the freed-up production capacities to manufacture, of all things, dishware. Such dishware, first of all, is both expensive to make and not very up-to-date—producers of airplanes and helicopters do not have the technology for manufacturing inexpensive, high-quality dishes. Second, we are depriving ourselves of our national legacy—our intellectual and technological experience, which was accumulated bit by bit in the leading areas of science and engineering.

USSR President M. Gorbachev also said something to that effect. Answering questions from deputies during the third session of the USSR Supreme Soviet, he admitted: "We need to thoroughly analyze the approaches to conversion right now. We did such stupid things in the initial stage, when we began using good productive capital and the manpower of our military-industrial complex and the defense sector for nonsensical ends. That could represent a great loss."

Something of a similar sort is also happening in space nuclear power engineering.

"The highly equipped, modern production operation intended for the series manufacture of nuclear-power units is now being converted for the manufacture of automatic systems for producing, of all things, milk cartons," said N. Ponomarev-Stepnoy. "We do, of course, need the milk cartons; there are many things we need for normal everyday life. But D. I. Mendeleyev said back in his time that burning oil was just the same as torching bank notes. The great Russian scientist never forgot the laws of economics. It would be totally irrational if our accomplishments in space nuclear power units were to be lost. It would be more like an attempt to stoke a furnace with antique furniture that was bought not with bank notes, but with gold. Can we really allow ourselves to act so unreasonably?"

"Aha, now the writer has let his secret out," the quick-witted reader exclaims. "Financing is being cut back, and the institute is on the brink of turning into a vegetable, and they're trying to persuade us that nuclear power sources are needed in space. If they fail to convince us, they'll be out of a job." Not quite. A talented scientist or engineer will never be without work, I assure you. He can join a cooperative, and at the worst, he could go to work making polyethylene bags and earn three times more than before. But none of us will profit from that. The leading countries are creating global communication systems. At the moment they are still asking us to cooperate with them. If we begin to shut down science-intensive areas, and thoughtlessly waste the potential we've built up over the years, our stock will drop quickly. And then they won't ask us anymore. That's something we need to think about.

A certain newspaper reproached N. Ponomareva-Stepnoy for supposedly selling our reactor to the Americans. First of all, he didn't sell it. Second, if he had sold it, what would have been so bad about that? It's far more profitable to sell a science-intensive product than to auction off raw materials at bargain basement prices. If the space program can't grow without nuclear power engineering, if high orbits guarantee safety, then we have to trade. We have both specific proposals and potential clients. However, the Atomic Energy Institute employs physicists, after all, and not businessmen. They need help, and not administrative directives such as "Convert at Any Price."

If we really wanted, we could turn the Tokamak into a pressure cooker. But do we need to?

Glavkosmos Chief Dunayev Interviewed on Moscow Aerospace Exhibition

LD2509221990 Moscow Domestic Service in Russian 1800 GMT 25 Sep 90

[Text] At the first international aerospace exhibition held in Moscow, a meeting between the leaders of Soviet space firms and journalists took place today. Our special correspondent Leonid Lazarevich interviewed Aleksandr Ivanovich Dunayev, head of Glavkosmos [Main Space Administration]

[Begin recording] [Lazarevich] Aleksandr Ivanovich, the exhibition has coincided with the completion of the first stage of the Soviet-German project Kazimir.

[Dunayev] The essence of the project was that on the "Foton" object created by the Central Council of Design Bureaus, we took the commercial cargo of the Kaiser Threde firm into orbit and provided for the fulfilment of the entire program. The experiment was carried out successfully. It was not the first experiment with this firm. Next year we plan about three experiments.

[Lazarevich] The firm's representative reported that very valuable catalysts were obtained, which presumably will be used in the oil industry. Glavkosmos already has

orders from abroad worth over 50 million foreign currency rubles. This exhibition showed the interest of foreign specialists in our space technology.

[Dunayev] Special interest was shown by French specialists who are now seeking cooperation with us. The French specialists were very interested in our powerful engines. They admired our complex at Baykonur—the elegance and the simplicity of these designs compared to the designs they have at Ariane complex. They are very interested in our space achievements, but our task is not to conclude immediate contracts. We are working today in this direction and the exhibition is not over yet. I think in a day or two we will know for sure what we will get from it.

[Lazarevich] The allocations for space research are being cut now; in any case there is a lot of talk about it. Can foreign orders fill in the capacities that are being freed?

[Dunayev] It all depends on the efficiency of the actions of our Glavkosmos as well as on the efficiency of the enterprises themselves. This is the main goal we are working toward now. [end recording]

FRG Firm, NPO Energiya Sign Memorandum on Cooperation

LD2609225190 Moscow Television Service in Russian 1700 GMT 26 Sep 90

[From the "Vremya" newscast]

[Summary] Oleg Kolin reports on a promising joint enterprise. The well-known West German communications firm ANT Bosch Telecom is interested in developing relations with the Energiya Scientific Production Association in Kaliningrad, founded by Academician Korolev, where Molniya-1, the first communications satellite, was made. The Soviet enterprise proposes to use the Energiya rocket to launch heavy communications satellites into orbit. The all-Union Association Energiya-Marafon was recently set up in order to carry out the project. A memorandum on cooperation between the Association and ANT Bosch Telecom was signed yesterday.

Commentary on Agreement for FRG Cosmonaut To Visit Mir Station in 1992

907Q0086 Moscow IZVESTIYA in Russian First Edition 19 Apr 90 p 6

[Article by S. Leskov: "A New Joint Flight"; first paragraph is source introduction]

[Text] **An agreement was signed on Wednesday in Moscow regarding the flight in 1992 of an FRG cosmonaut on the Soviet Mir orbital station.**

Our space sector is committing itself ever more deeply to a commercial footing, and the issues of the economic efficiency of space research are becoming ever more important. Of importance in that regard are joint flights, the price of which, for eight days of work in orbit, varies at $10-12 million. Contracts have already been signed regarding work aboard the Mir orbital complex by researchers from Great Britain, Austria, and France and a journalist from Japan; other agreements have been signed on the use of space information. In the opinion of the head of USSR Glavkosmos, A. Dunayev, the payments, which have begun to come in on these contracts, will help overcome the sector's strained financial situation. After all, for the 1990 manned mission program alone, just under 300 million rubles are needed, and only around 220 million rubles have been allocated from the state budget. The space program is supposed to "earn" the 70-80 million-ruble shortfall itself, and here hopes are pinned on, among other things, foreign contracts.

What is unique about the flight of a cosmonaut from the FRG? Obviously the problem of the selection of candidates is made simpler. FRG already has its own small, but professional cosmonauts corps, and three individuals have already participated in two flights on the American space shuttles. Plans are being made now for another FRG cosmonaut to fly as part of an American crew. It is being proposed that four FRG cosmonauts be trained in the American program, and two in the Soviet program. Thus, the whole problem centers on just how best to divide up the West German cosmonaut corps.

"I believe that, physically and mentally, our cosmonauts are as ready for a flight on a Soviet craft as they are for a flight on an American craft," Professor V.-S. Kroll said in response to a question from an IZVESTIYA correspondent. "Thus, the specific flight program will decide a lot of things. It will be necessary to take into consideration here the fact that there are two women in our corps and that the range of specialties is quite broad—physicists, a meteorologist, and a doctor. But each cosmonaut has worked at the largest European universities and has mastered practically all the space-related specialties. What will also have a definite effect on the selection, obviously, will be the candidate's ability to learn Russian. We are hoping that our consultant, Sigmund Jaehn, general of the People's Army of the GDR and the first German cosmonaut, will help us consider the special features of the Soviet space program."

The agreement was signed by Professor V.-S. Kroll, chairman of the board of the German Aviation and Space Research Society, V. Ignatov, chairman of the Litsensintorg All-Union Foreign Trade Association, and Yu. Semenov, general designer of the Energiya scientific production association. In orbit, a great deal of attention is expected to be paid to materials science, biotechnology and medical experiments, which will be a logical extension of the work performed by the FRG specialists on the American spacecraft. The FRG cosmonaut will be able to bring around 10 kilograms of materials obtained in weightlessness back to Earth in the reentry vehicle.

Commentary on PRC Satellite Launch

907Q0081 Moscow IZVESTIYA in Russian 15 Apr 90 First Edition p 5

[Article by IZVESTIYA correspondent Yu. Savenkov, Beijing, under the rubric "IZVESTIYA Correspondents Comment: China": "A Satellite for 2.5 Billion People"; first paragraph is source introduction]

[Text] **A Chinese Long March-3 rocket placed into a geostationary orbit the Asiasat-1 commercial communications satellite, which was made in the USA and belongs to a private consortium of the same name, in which English, Chinese and Hong Kong capitals are participating**

The launch took place last Saturday from the Chinese space launch facility in Xichang in the southern part of Sichuan Province. Dry, clear weather is traditional for this time of year, and it did not let them down for the launch. Although a momentary whim of the weather which delayed the launch for an hour and a half did, of course, cause some concern among all those who had gathered here. In addition to the space center workers and officials, witnessing the event were hundreds of local peasants who had climbed to the tops of the hills that fringe the launch pad.

The Chinese press is rating the event in superlative terms. That is understandable. First of all, a Chinese rocket had placed an American satellite into orbit for the first time. Recall how the events unfolded dramatically. In late 1988, after a lot of maneuvering, the American government approved an export license for the launch of American satellite by Long March rockets. In the process, the "control over the export of technology to socialist countries" syndrome had to be overcome. Then the dramatic events in June of last year in Beijing drew economic sanctions from the West, plus a new wave of protests by U.S. congressmen against the space deals. And it was only this year that President Bush, based on "U.S. national interests," gave the green light to the operation which culminated in the launch in Xichang.

Second, this satellite is a commercial one, which means the Chinese Great Wall Corporation has finally managed to negotiate the thorny path to the international space services market. Until now, it had managed only episodically to offer space for foreign companies' scientific equipment on recoverable space vehicles. The placement into orbit of a foreign satellite is a "breakthrough."

Third, this launch opens up a new stage in the development of telecommunications and other communications in Asia. As soon as the 6-week cycle of testing of all the systems ends, the transmission and reception of signals will begin from the enormous area of central and southern Asia, where 2.5 billion people live.

What is the satellite's purpose? Some 80 percent of its capacities will be used for television programs. In addition, there will be high-speed data transmission, facsimile service and international telephone services. Each of the satellite's 24 channels, for example, is ready to accept 1,000 telephone signals simultaneously. There is also a built-in capability for switching to the international satellite system for finding ships and aircraft in distress.

Several minutes after the launch, Asiasat's official representative, as the Hong Kong press reported, declared that his company is prepared to offer to China this fall, free of charge, six channels for the broadcasting of the Asiatic Games.

Specialists in Asiatic problems are certain that, in the future, the Asiasat-1 will exert influence on various aspects of life in Asiatic countries—social, business and economic. Some clients are already known—for example the Pakistan government is leasing a channel for educational television programs for remote regions. Among the clients is Thailand, although it is planning to launch its own communications satellite—but that is still years away.

The company has already received 30 applications from governments and private firms, which already exceeds the satellite's capabilities. Therefore, plans are being made for the launch of the Asiasat-2 in 1993. It will cover the same regions and will operate "in a single harness" with its brother. The experts say that such cooperation increases the efficiency not by a factor of 2, but by a factor of 16!

Li Peng, the Premier of the State Council, called the successful launch "proof of the maturity of the Chinese space industry and, first and foremost, of the orbital insertion system." But remember: the gap between China and the developed countries in this area is still large, and further efforts are needed.

USSR-China Space Cooperation

907Q0116 Baku BAKINSKIY RABOCHIY in Russian 1 May 90 p 1

[Article by S. Avdeyev: "Space—It's Profitable"]

[Text] **Within the framework of an agreement between the academies of sciences of the USSR and China, a delegation from the Chinese Academy of Sciences' Shanghai Technical Physics Institute visited USSR Glavkosmos's Space Research Scientific Production Association.**

The guests became acquainted with the work of the association's key laboratories and viewed the exhibition "Space—For the National Economy," whose displays included instruments for sensing the earth from space and hardware for deriving and processing aerospace information for the purpose of using it in the various sectors of the national economy. But the main thing is that talks were held about paths for possible cooperation, which concluded with the signing of a protocol of intentions. It was signed by Professor Yung She, head of the Chinese delegation and director of the Shanghai Technical Physics Institute's Remote Sensing Laboratory,

and Professor A. Mekhtiyev, first deputy general director of USSR Glavkosmos' Space Research Scientific Production Association.

The development of a long-term program for joint work in the field of the study of the earth from space may be announced, joint experiments may be conducted at the scientific production association's test sites, and aerospace systems for ecological monitoring may be developed. The systems would be used to solve ecological problems both in the USSR and in China.

What also promises to be interesting is the Kursk-90 joint aerospace experiment, in which, at a local test site, remote sensing equipment installed on an aircraft will be used to develop methods for determining the parameters of the condition of the vegetation cover and the soil. And, of course, a regular exchange is expected between the delegations.

"The cooperation of Azerbaijan and Chinese specialists will not only help solve purely scientific problems," said Sh. Agayev, director of the Space Research Scientific Production Association's Kosmik Commercial Center, "but also many down-to-earth concerns. Having been granted the right to act independently—including the signing of agreements—plus the right to produce products and to render services, we are not only studying the demand, we are also attempting to satisfy it. For example, a program of scientific cooperation with the Erzurum Ataturk University on problems of seismic tectonics and earthquake prediction has been approved. Talks have been held with a number of foreign scientific research organizations and firms on the subject of cooperation and the organization of joint ventures for the manufacture of science-intensive products, computer equipment, household electronic equipment and office equipment. In the future, cooperation is possible for the establishment of an international computer communications center (involving satellite communications facilities) and the organization of a commercial information network based on it.

It would be hard right now to find a sector of the national economy that would would not be able to use information derived from space. Aerospace information is currently making it possible to solve more than 300 scientific, industrial and environmental problems. The return provided by space-based research on natural resources is estimated to be 10-15 rubles for each ruble spent.

According to the specialists' predictions, by the year 2000, space-based research will bring our state annual profits of 50-100 billion rubles. The first steps on the path of commercial activity are being taken by the Space Research Scientific Production Association.

Commentary on U.S. Development of Anti-Satellite Weapons

LD0111183190 Moscow TASS in English 1743 GMT 1 Nov 90

[By TASS military analyst Vladimir Chernyshev]

[Text] Moscow November 1 TASS—Development of anti-satellite weapons is continuing in the United States. According to the SPACE NEWS weekly, the U.S. Army has placed orders with the Rockwell International Corporation for new-type interceptor missiles to destroy "enemy" satellites. There is a program to develop a system of anti-satellites weapons by 1995. They will include ground-based laser components.

Frankly speaking, it is difficult to grasp the Pentagon's logic. On the one hand, it agrees that there is no more cold war or any danger of a surprise attack, and, on the other, steps up the efforts to develop anti-satellite weapons. From the strategic point of view, such weapons are intended to preclude the other side's retaliation. Moreover, they create a danger to early warning and emergency communications satellites. Deployment of anti-satellite systems would undermine strategic stability at a time when top U.S. officials do lip service to its consolidation.

And one more thing. Development of anti-satellite weapons contradicts the strategy of "nuclear containment." In American interpretation its purpose is to make all sides refrain from attacking out of fear of prompt retaliation. And can there be any sense in reciprocal "containment" if one side strives to possess weapons capable of lessening the other side's chances to strike back?

One more thing is absolutely clear. The other side will be compelled to take similar steps to avert the danger of the other side's anti-satellite systems. Therefore, any steps to develop anti-satellite weapons are fraught with the danger of the arms race spreading into outer space. It is surprising that some people fail to realise the absurdity of all this in light of the current military-strategic situation.

The Soviet Union has long since offered the United States to conclude an agreement on the complete banning of spatial strike weapons, including anti-satellite systems. It also moved to scrap the already existing armaments of this type. But the U.S. Administration refuses to heed these proposals.

According to U.S. Deputy Assistant Defence Secretary Douglas Graham, the Reagan Administration had arrived at the conclusion that it is impossible to control anti-satellite weapons and that there are no control measures "meeting the interests of U.S. national security."

The Bush Administration got down to a "comprehensive investigation" of the problem, and although it is still

under way, the conclusion has already been made that control problems are "unsurmountable."

The Soviet Union is of a different opinion. All difficulties linked with the banning of anti-satellite weapons can be overcome given the desire of both sides. This is even more feasible now that mutual trust has grown substantially between the USSR and the United States, between the East and the West.

U.S. Reluctance on Space Cooperation Criticized

PM0611152290 Moscow KRASNAYA ZVEZDA in Russian 2 Nov 90 First Edition p 3

[By A. Yakimenko "Rejoinder": "What Lies Behind Good 'Intentions'"]

[Text] NASA Director R. Truly was in Moscow recently at the invitation of the USSR Ministry of General Machine Building and the "Intercosmos" Council of the USSR Academy of Sciences.

Even before the meeting began it was possible to assume that the leaders of the space departments of the world's two greatest countries had something to say and show to each other and something on which to reach agreement in the sphere of concrete mutually advantageous businesslike cooperation. For not even the most fault-finding and qualified foreign specialist would be ashamed to take into account and utilize very many of our achievements. We have to our credit technical and medical-biological support for long manned flights, powerful and reliable booster rockets, and a developed infrastructure of scientific and production projects—a guarantee of further progress in cosmonautics.

However, in the process of the meetings which took place in the headquarters of our cosmonautics, in plants and institutes where it was possible to see the most modern space technology projects, and at the Cosmonaut Training Center it was only the possible areas of cooperation, as your correspondent learned, that were discussed, and the meeting resulted in a protocol of intentions. But there are sometimes "huge distances" to cover from intentions, however good they may be, and generalities to practical deeds. Neither diplomatic bowing and scraping, nor expressions of gratitude for invitations, nor nostalgic memories of joint work while realizing the "Soyuz-Apollo" project have yet ensured the expansion of the barely glimmering contacts that were started up after the signing of the 1987 Soviet-U.S. agreement on cooperation in the sphere of space. Incidentally, a similar opinion is also voiced in the U.S. press, in particular in AVIATION WEEK AND SPACE TECHNOLOGY magazine.

Meanwhile, both U.S. and Soviet firms and scientific organizations are very interested in the mutual utilization of the achievements of space technology and in the further development of contacts in this promising sphere.

What is the problem? It is obviously that it is impossible today to take a single step in practical space cooperation without the sanction of the highest leadership in Washington.

It seems that in specific matters these leaders fail to keep pace with their own very promising statements about new political thinking and the restructuring of the two countries' relations along democratic lines. Obviously, there is also the calculation that it is still possible to stand firm within the framework of the regulations of the notorious Coordinating Committee for Multilateral Export Controls, which, as is known, prohibit the transfer of advanced Western technologies and even the Soviet side's familiarization with them and which the world public today regards not only as a means of infringing on USSR's interests but also as a means harming the United States' own economy.

Or maybe NASA is simply sounding out future partners, or maybe an in-depth familiarization with each other's possibilities is still taking place, as is always done before concluding any serious deal?

I would like to believe this.

Space Surveillance System Described

91UM0040A Moscow KRASNAYA ZVEZDA in Russian 10 Oct 90 First Edition p 2

[Article by Lieutenant Colonel A. Dokuchayev, KRASNAYA ZVEZDA correspondent: "A Bridle for the Nuclear 'Racers,' or What the Space Monitoring System Represents"]

[Text] **We are completing an article on strategic deterrence systems that are at the disposal of the USSR Armed Forces.** (See KRASNAYA ZVEZDA of 27 September and 5 October.) Today's material is about the outer space monitoring system (SKKP).

Colonel V. Nikolskiy pointed to an enormous bay with displays and multicolored screens—the command post of the space monitoring system. He says look and study.

"From here we see practically the entire moving cosmos," he explained.

I familiarize myself with what yesterday was an inaccessible and top secret facility. Dozens of questions crop up. First: Why do we need this very modern and expensive all-seeing eye?

Colonel G. Kovsh, chief of the department who was keeping up the conversation, answers one question after another: "Do you know how many objects there are in outer space? More than 7,000 have been counted, active and inactive satellites.... We are talking about those that are placed in orbit. All told there are more than 20,000 flying objects—outer space is cluttered. Out there a very ordinary needle is capable of piercing a spacecraft and causing trouble. But the problem is not in the number—not all space apparatuses are harmless...."

He showed a short chronicle of recent reports from abroad.

"16 July. Pakistan launched its first Earth satellite vehicle, weighing 50 kilograms, from Chinese territory. According to the announcement of the prime minister, this is 'an important event on the road to the technological modernization of Pakistan.'

"1 August. A missile whose electronic components were undergoing testing in the air for the 'Star Wars' program went off course and was destroyed on a command from Earth. The destruction command came from the White Sands test range (state of New Mexico).

"4 August. A Delta-2 rocket was launched from the space center on Cape Canaveral. Its main objective—to put a Navstar system satellite into orbit—pursuant to a Pentagon program...."

"Different, very different satellites are being put into orbit, and they simply are real dragons. Once outer space becomes more dangerous, then we must know everything," says Viktor Nikolskiy, "or almost everything about each apparatus and object. These tasks surfaced as early as the beginning of the 1960's, and they were prompted by the placement of satellites into orbit that had a military purpose."

Like every new program, the system for monitoring outer space was born as they say with birth pangs. The original provision of space object tracking was accomplished through information obtained by optical systems of the USSR Academy of Sciences and the Air Defense Troops, with the use of plotting boards and individual programs.... But with the passage of time this became inadequate. Powerful radars of the missile attack warning and the antimissile defense systems were linked up in the tracking of objects. The streams of information were transformed into a real river that was full-flowing and rapid. The question arose as to the speedy and effective processing of information. And so in 1970 a space tracking center began to be created. N. Buslenko, G. Ryabov, and their colleagues performed a great service in this.

A kind of personal file is kept on each high-flying "traveler"—it contains the satellite's coordinates, its capabilities, and its "behavior". A catalog is constructed from this kind of personal data. When the task arises to take a closer look at one or another space wanderer—for example, the U.S. reconnaissance satellite Ferret-D—the catalog helps find its location area quickly, and only then do the tracking complexes "tell" where it is located and give its characteristics. With what kind of accuracy? They explained it to me. Imagine that two soccer balls are flying at a distance of 10 centimeters from each other. We will say that there are two balls in orbit, and not one. But this is a figurative comparison. There are also examples of specific work that attest to the professionalism of the collective.

September 1983. A South Korean Boeing-747 aircraft violated the state border of the USSR, intruded into our country, and was shot down by a Soviet fighter. People died, a tragedy occurred. The world had to be told who was responsible. The Soviet side presented evidence that the intrusion into our airspace was intentional. Perhaps the most convincing evidence was that presented by the space tracking center. The flight of the Boeing-747 was very carefully synchronized with the flight of a Ferret-D reconnaissance satellite. The space spy appeared over Chukotsk at 1845 on 1 September, and for a period of approximately 12 minutes it flew to the east of Kamchatka and the Kuril Islands, monitoring Soviet electronic systems which were working in the normal mode. In the next orbit, the Ferret-D appeared over Kamchatka at exactly the moment of the intrusion of the encroaching aircraft, fixing the activity of our communications and electronic systems which were changing the intensity of their work. In the end, it was established that the third orbit coincided with absolute accuracy with the following third stage of the Boeing-747 over Sakhalin. The data presented to the public showed: Such an exact coincidence of the flight of the reconnaissance aircraft and the spy satellite cannot be explained away as accidental.

Mistakes must not be made in such cases. A tremendous responsibility is placed on equipment, and most of all on people. Who are they, the "controllers" of outer space?

The operations duty officer is Colonel V. Minayev. He is 49 years of age, has completed a military school and a military academy, and is married and has children. He is from the Kharkov area. Lieutenant Colonel Ya. Tsymbalistyy, a member of the team, also comes from the Ukraine. "I also have a connection with the Ukraine," says Major N. Davydov. "I graduated from a military school there."

A lot can be told about each of them. Take Yaroslav Tsymbalistyy. He has been here since the beginning. He assembled the electronic apparatus of the automated control system—specialists from the manufacturing plant were amazed: Where did such knowledge come from, and such skill?—he studied it, and now he is operating it. He can say with complete justification: "my center."

"Competence is the main thing that characterizes the officers of the center. Other specialists 'do not survive here,'" said Colonel V. Nikolskiy. He talked with pride about the fact that this year alone 20 medalists came here from military schools. "Very high knowledge and solid skills are the main requirement for holding conversations with outer space. An aspiring person next to wonderful equipment cannot help but grow...."

Incidentally, this is understood very well in the higher educational institutions and in the scientific research institutes, and they eagerly invite officers who have worked well in the tracking center. They have more than

one research work to their credit. Officers Yu. Gorobchuk, V. Zyubin, and M. Chernov recently defended their candidate dissertations.

"Is it difficult to be an officer in the SKKP?" I could not refrain from asking Minayev this banal question.

"Speaking for myself, it is difficult," he answered. "Today, the situation here is more or less quiet, but it is not always this way. For example, one of our tasks is to track space objects in the descent sector—we get precise information on the point of impact, and we issue information about this. And what are the satellites like now? There are those with nuclear equipment. When can they be expected? Where will the fragments fall...?"

Vladimir Minayev and his colleagues had occasion to worry some in the spring. It all started on the 8 March holiday. Four new fragments appeared in space. The analysis and data processing group reported: These are parts of a satellite that was put into orbit by the American spacecraft "Atlantis." It would seem it was nothing to worry about, but the object was not a simple one, and it was launched in the interests of the Pentagon—for visual and electronic intelligence, and its weight was 17 tons. Apparently the Americans blew it up because of defects. A precise answer had to be given: Where will the parts fall? Will they burn up completely in the atmosphere. The specialists did not err in their calculations. The first fragment burned up in the thick layers of the atmosphere on 19 March 1,500 kilometers to the north of Midway Island in the Pacific Ocean. They explained that the rest of the fragments do not represent a danger. Of course, their attention did not slacken until all of the fragments "died."

"There is also work with the manned spacecraft," explains Colonel Kovsh. "But we get involved only in an emergency situation. If an orbital station or a spacecraft is being guided, and close communication is being maintained with them, then here as the saying goes our job is on the sideline. But if a malfunction should occur, and the Mission Control Center 'loses' its envoys, then it cannot do without us...."

Grigoriy Kovsh showed TASS information appended to a file. "Several corrections in trajectory movement were made during the two-day automatic flight of the Soyuz T-13, as a result of which the spacecraft approached the Salyut-7 station at the prescribed distance. Further closing was executed by the crew manually with the use of a range determination apparatus and the onboard computer system." It was not reported then that Vladimir Dzhanibekov and Viktor Savinykh executed the docking with the silent station that was "lost" by Mission Control Center, and that they found it only with the data that was issued from here, from the space tracking center.

...Of course the collective does not live only with celestial distances. Here as in any garrison weddings are celebrated, apartments which are not in surplus are awaited impatiently, there is gossip about the shortage of commodities, there are holidays, and it is a blessing that the military facility is situated in a refreshing coniferous forest. But nevertheless, the main thing that determines everyone's mood is outer space, and more precisely monitoring it. When I tried to distract officers from discussions about work and to talk about everyday living matters, it did not always work out and they only steered away from the subject. They spoke with bitterness about the fact that frequently specialists from the space department took credit for the tracking center's work, and that they were being taken advantage of because of their secrecy. You see, no one else can spot falling fragments and pinpoint the coordinates of silent satellites....

Here in the tracking center they understand that the process of disarmament that has been started will not affect them—the outer space monitoring system will be needed even when there are no armies. The main concern is not to fall behind in the rapid exploration of outer space in order to secure their fellow citizens from various accidents. Indeed, the military danger from outer space has not been removed. On the days that I was in the tracking center, the Pentagon carried out a regular experiment in launching a powerful energy device within the framework of the "Star Wars" program. It appears that these warriors are assured this complex work for a long time. We will not shy away from giving credit to them for their unobtrusive work—so important and necessary in behalf of our security and peace—which for many years has been guarded by a curtain of secrecy.

Obituary of Col Gen A.A. Maksimov, Head of Ministry of Defense Space Section

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[Obituary of A.A. Maksimov]

[Text] Colonel General (Retired) Aleksandr Aleksandrovich Maksimov, participant in the Great Patriotic War, Hero of Socialist Labor, Lenin Prize and State Prize laureate, candidate of technical sciences, has died suddenly at the age of 68.

A.A. Maksimov was born on 29 August 1923 in Moscow. In 1941, he voluntarily joined the ranks of the Soviet Armed Forces, where he traversed a path from student at an artillery school to colonel general.

When participating in the Great Patriotic War, A.A. Maksimov displayed boldness and courage, for which he was awarded combat honors. In May 1943, he became a member of the CPSU, and he remained loyal to its ideas to the end of his days.

During the postwar years, A.A. Maksimov graduated from the Military Academy imeni F.E. Dzerzhinskiy and all his subsequent service activity was devoted to the development, production, assimilation, and operation of space rocket technology. He was for many years head of the space section in the USSR Ministry of Defense. He

played an active part in the preparations for and execution of the missions of the first artificial Earth satellite, the first cosmonaut, the universal "Energiya-Buran" space rocket transport system, and many other manned space vehicles, satellites, and interplanetary stations.

In all the posts to which he was assigned, A.A. Maksimov applied all his strength, knowledge, experience, and organizational ability to enhancing the country's defense capability and consolidating the position of Soviet cosmonautics. He was distinguished by a high level of competence and sense of responsibility for his assignments, an exceptional love of work, a sense of principle in resolving the tasks set for him, and also fine human qualities; a generous soul, loyalty in friendship, and attention and concern for his subordinates.

A.A. Maksimov played an active part in sociopolitical life and was elected as a delegate to the 27th CPSU Congress and the 19th All-Union Party Conference. A.A. Maksimov's services were highly valued. He was awarded the title Hero of Socialist Labor and was decorated with two Orders of Lenin and many other state honors, and also with orders and medals from foreign states.

The bright memory of Aleksandr Aleksandrovich Maksimov, loyal son of the Soviet people and true and ardent patriot of the socialist homeland, will live forever in our hearts.

[Signed] M.S. Gorbachev, A.N. Lukyanov, N.I. Ryzhkov, Yu.D. Maslyukov, D.T. Yazov, O.D Baklanov, L.N. Zaykov, I.S. Belousov, M.A. Moiseyev, P.G. Lushev, K.A. Kochetov, N.I Shlyaga, Yu.P. Maksimov, V.I. Varennikov, I.M. Tretyak, Ye.I. Shaposhnikov, V.N. Chernavin, V.M. Shuralev, V.M. Arkhipov, V.M. Shabanov, N.V. Chekov, V.L. Govorov, V.F. Yermakov, Yu.A. Yashin, O.N. Shishkin, A.N. Soshinkov, V.L. Ivanov, I.I. Kurinnyy, G.S. Titov, S.N. Yermak, V.M. Ryumkin, G.F. Lysenkov, D.D. Maslyukov

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